A Study of US Government's Satellite Incumbents and Follow-on Competitions

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ABSTRACT

In many high technology industries, incumbents routinely find themselves loosing to new entrants as well as established competitors in the battle for leadership across successive generations of new technology. However, the demise of the incumbent is most typically associated with the entry of start-up firms particularly in settings with minimal complementary assets, few intellectual property rights and limited technical expertise.

This thesis will explore a different competitive setting - the U.S. Government's unclassified satellite competitions – an arena characterized by deep technical skills, strong and lasting complementary assets and robust IP. Given these strengths, we would expect to find that incumbents would successfully win most competitions. In fact, according to newly gathered data, satellite producers for the U.S. Government have historically experienced an almost 90% loss rate in follow-on satellites competitions. This pattern is prevalent in satellite competitions undertaken by the National Aeronautical and Space Administration (NASA), the National Oceanographic and Atmospheric Administration (NOAA), the United States Air Force (USAF) and the United Stated Navy (USN). The winners of these competitions are not to new entrants into the satellite business, but rather they are other established aerospace companies – suggesting that it is more than "organizational newness" that leads to success and more than age that leads to obsolescence.

Anecdotal drivers of this trend abound, however, there is no systematic examination of the satellite industry and few settings in which the loss of incumbents to other large and established firms have been extensively analyzed. This thesis is an attempt to unravel the puzzling and repeated loss of incumbents to organizations that are in many ways very similar in terms of size, bureaucracy, technology etc. and yet which seem to be able to out-compete the winners of prior competitions over 90% of the time.

This thesis argues that three factors drive this trend:
1. Non-incumbents leverage new architecture innovations to provide superior performance
2. Non-incumbent management encourages pursuit of architectural innovation
3. Non-incumbent optimistic bias enables aggressive bidding to win.

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To my parents for their patience and belief in my potential.

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1. Introduction

> *"..., we must guard against the acquisition of unwarranted influence, whether sought or unsought, by the military industrial complex."*
>
> \- Dwight D. Eisenhower - January 17, 1961

> *"We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard..."*
>
> \- John F. Kennedy - September 12, 1962

Access to space is inherently high risk, complex and an expensive endeavor. The rewards of human exploration, scientific discovery, and technological advancement continue to drive state of the art boundaries and engineering innovation with each new mission.

U.S. Government satellites provide unique economic and national security benefits to its citizens and allies. Earth resource satellites can scan the entire earth in a single day to monitor global climate change. One Geosynchronous (GEO) communication satellite can view one-third of the planet, and provide military communications where none are available. Global Position Satellites (GPS) provide position accuracy less then 100 meters anywhere in the world to military and civilian users. Weather satellites provide real time imagery of weather and storm forecasting vital to economic activity and human safety. In broad terms, these are no practical substitutes for these satellites.

Despite these miraculous advances, cost overruns and schedule delays continue to plagued new missions. In 2006, estimated costs for the United States (U.S.) Department of Defense's (DOD) major space acquisition programs for fiscal years 2006 through 2011 have increased over 40 percent or $12.2 billion from initial estimates (GAO 2006).

Cost and schedule delays of large government projects receive significant oversight by the U.S. Congress (GAO, 2003, 2005, 2006, 2007). Independent studies, "Blue Ribbon" panels, and media provide a plethora of scrutiny. These issues ultimately cause serious deficiencies to the users who rely on the systems to perform their mission. Operational challenges are compounded when follow on systems are late in replacing older failing systems and potential gaps in service arise.

Anecdotal perspectives - as well as in-depth study and analysis – articulate a commonly accepted rationale; contractors "buying in" with low bidding, politicians seeking job creation to their constituents, government employees creating empires, inexperienced personnel, budget and requirements instability, etc. These rationale certainly cannot to be discarded, and in many cases may cause significant deficiencies for the ultimate intended users. Cristina T. Chaplain, Director Acquisition and Sourcing Management Team of the Government Accountability Office (GAO), testified before the Subcommittee on Strategic Forces, Senate Committee on Armed Services, (GAO, 2007):

> *"... on a broad scale, DOD starts more weapon programs than it can afford, creating a competition for funding that encourages low cost estimating, optimistic scheduling, over promising, suppressing of bad news, and, for space programs, forsaking the opportunity to identify and assess potentially better alternatives. Programs focus on advocacy at the expense of realism and sound management."*

A report issued by the Defense Science Board/Air Force Scientific Advisory Board Joint Task Force in May of 2003 on Acquisition of National Security Space Programs studying cost and schedule overruns of major U.S. Depart of Defense (DoD) satellite contracts elaborated:

> *Unrealistic estimates lead to unrealistic budgets and unexecutable programs. The space acquisition system is strongly biased to produce unrealistically low cost estimates throughout the process.... Proposals from competing contractors typically reflect the minimum program content and a "price to win." ... An incoming competitor is not "burdened" by the actual cost of an ongoing program, and thus can be far more optimistic.*

Additionally, the Task Force identified a significant phenomena– the failure of incumbent contractors in these competitions:

> *"Analysis of recent space competitions found that the incumbent contractor loses more than 90 percent of the time."* (Young)[1]

The report does not contain a summary of programs, but a gathering of contract awards shown in Table 1.1 supports the Task Force findings.

Table 1-1 Summary of U.S. Government Unclassified Satellite Competitions

	Year	New Program	Incumbent	Follow On	Winner	Cost	Tech
USAF	1971	IDSCP	Ford (loral)	DSCS II	TRW	n/a	n/a
USAF	1982	DSCS II	TRW	DSCS III	GE (LM)	n/a	n/a
USAF	2001	DSCS III	LM	WGS	Boeing	1	1
USAF	1990	GPS IIA	Rockwell	GPS IIR	LM	1	1
USAF	2005	GPS IIR	LM	GPS IIF	Boeing	1	1
USAF	1996	DSP	TRW	SBIRS	LM	1	1
USAF	2000	Milstar	LM	AEHF	LM	Sole	Source
USN	1979	FLTSATCOM	TRW	Leasat	Hughes	1	1
USN	*1988*	*Leasat*	*Hughes*	*UHF Follow On*	*Hughes*	*1*	*1*
USN	2004	UHF F/O	Hughes	MUOS	LM	n/a	1
NASA	1995	EOS-AM-1	LM	EOS Common	TRW	1	1
NASA	1995	TDRS 1-7	TRW	TDRS H,I,J	Hughes	1	1
NASA	2002	Hubble	LM	NGST	TRW	2	1
NOAA	1977	GOES 1-3	Ford (Loral)	GOES 4-8	Hughes	1	n/a
NOAA	1985	GOES 4-8	Hughes	GOES I-M	Loral	1	n/a
NOAA	1997	GOES I-M	Loral	GOES N-Q	Hughes	1	1
NOAA	2002	DMSP/TIROS	LM	NPOESS	NG	1	1

NOTE: For Cost 1 = Lowest; For Technical 1 = Best; n/a = not available

[1]Report of the Defense Science Board/Air Force Scientific Advisory Board Joint Task Force on Acquisition of National Security Space Programs May 2003 pp1-82, pg 10

This phenomenon is not restricted to DoD satellite programs represented by United States Air Force (USAF), and United States Navy (USN) satellite programs. The trend is also prevalent in major satellite programs from the National Atmospheric and Space Administration (NASA) Goddard Space Flight Center (GSFC) and National Oceanographic and Atmospheric Administration (NOAA) satellite programs.

Although each agency procures these satellites through the same U.S. Federal Acquisition Regulations (FAR), each agency develops its own mission requirements and follows procurement polices to suit the particular needs of that agency. These agencies also have their own distinct cultures driven by mission needs and individuals that support those needs (i.e. scientific research, vs. War fighting operations).

This phenomenon is additionally puzzling as incumbents in large satellite contracts enjoy a customer franchise with uniquely configured technology and contracts lasting 10 years or longer. Barriers to entry and exit are high, making contractor-switching costs prohibitive. Political constituencies of large budget programs make canceling a program additionally difficult. Intuitively one would expect incumbent contractors to have an edge against new entrants in follow on contracts. Jacques Gansler, former Under Secretary of Defense for Acquisition, Technology, and Logistics, (1997 to 2001) provides a perspective that supports why incumbents have a unique advantage, but also might provide an underling element of why government chooses someone else for the follow on competition.

> *".... once the winning development contractor is announced, the . . . sole-source supplier is in an increasingly powerful position. As time goes on, the government becomes more and more dependent upon this contractor for a product that is (or is believed to be) badly needed and for which no substitute could be developed in less than seven to ten years."*. (Gansler, 1980)

Thesis Questions

While cost overruns and schedule delays are cause for serious concern, the perspective of an "unburdened" new entrant biding to a "price to win", ("buying in") maybe an oversimplification of underlying phenomena. The pattern of incumbents losing to new entrants or non-incumbents has been documented in a range of industry settings (Abernathy and Clark 1983, Foster 1986, Henderson and Clark 1990, Utterback 1996, Christensen 1997). Across these varied sectors of the economy, a number of academic theories have been developed to explain this phenomenon.

Building on these theories, this thesis sets out to address the question of why incumbent satellite makers lose in 90% of follow-on competitions. This question is examined using a combination of quantitative data gathered from government programs, together with in-depth interviews with 18 individuals closely involved in satellite competitions – from suppliers, government contractors, consultants, and acquisition decision makers. Based on this evidence, I argue that incumbent losses are driven by three factors. First, non-incumbents leverage new architectural innovations to provide superior performance, second, non-incumbent management encourages pursuit of architectural innovation, and third, non-incumbent optimistic bias enables aggressive bidding to win.

The following chapters provide the background, methodology and analysis to support this conclusion. Chapter 2 lays out the empirical setting and Chapter 3 reviews academic literature on innovation factors influencing technical and managerial decisions. Chapter 4 studies three specific competitions. Two of the three incumbents lose the follow on competitions, and a third provides a rare case in which the incumbent successfully wins a full and open competition.

Chapter 5, complies the interviews and assesses common characteristics. Chapter 6 provides the conclusion and recommendations for future follow on competitions.

2. Empirical Setting

> *"...not only the United States, but countries throughout the world are dependant on space based technologies, weather satellites, communications satellites and other devices to be able to conduct modern life as we know it."*2

This thesis studies the unclassified U.S. government satellite business by government agencies including National Oceanic & Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), The United States Navy (USN), and The United States Air Force (USAF). The specific setting is competition for large follow-on programs to replace existing operational systems that are reaching the end of their useful life. These satellites are procured by full and open competition via a Request for Proposal (RFP) under Federal Acquisition Regulations (FAR). For purposes of this thesis, "large" is defined by a contract value greater then $250M in 2007 dollars. The programs are typically for multiple (i.e. 3 to 5) large satellites greater then 500 kilograms, along with associated ground communication and data dissemination systems. From initial customer interest to contract completion, 10 to 15 years may elapse. With contract extensions, 20 or 30 years may pass before a follow on competition occurs. Despite the large U.S. space budget, only one or two contracts awards occur in any one year. The capability to compete credibly in this class is limited to a few large U.S. aerospace companies. These companies frequently team with each other for competitions and thereby further limit viable competitors to only two or three. High cost of capital, intellectual property, intellectual capital, and complimentary assets create significant barriers to entrance. This chapter provides further empirical setting to the thesis in three primary areas: satellite system overview, U.S. Government satellite market, and the acquisition process.

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[2] U.S. State Department Daily Press Briefing Tom Casey, Deputy Spokesman, January 19, 2007. DoS press release in response to a Chinese anti-satellite weapon test.

2.1 Satellite Architecture Overview

A general architecture description encompassing the major elements of satellites discussed within this thesis shown in figure 2.1. The systems are certainly more complex, but this section provides sufficient overview and fidelity for purposes of this thesis.

Satellite orbits provide the fundamental mission effectiveness. Geosynchronous Earth Orbits (GEO) enable fixed viewing over a geographical location enabling continuous services such as communications or weather observation. Medium Earth Orbits (MEO) provide global coverage utilizing a constellation of satellites such as the Global Position System (GPS). Low Earth Orbits (LEO) enable high-resolution imagery or short time delay for higher quality voice communications as GEO time delays are 0.25 seconds causing noticeable time quality delays. Numerous other orbits offer additional tradeoffs in architecture development. Within orbits, location placement and numbers of satellites add to architecture complexity. Follow on competitions revisit these trades to assess new mission requirements.

The primary segment is the space segment, which may contain one or a constellation of several satellites. For example, GPS requires 24 operational satellites to provide complete global service. The two key elements within the space segment defined for purposes of this thesis are the satellite bus and the mission payloads. The satellite bus consists of several subsystems (i.e. power, data, structure, thermal management, guidance, navigation, and control, etc.) which support the mission payload and operation of the satellite. The mission payload may contain several payloads. A single mission need drives the design of the payload(s); however, other mission payloads are occasionally supported as a matter of convenience if excess satellite accommodation resources are available. In general, the prime contractor provides the satellite bus as it is integral to the mission operation (i.e. orbit, mission, operations, etc.).

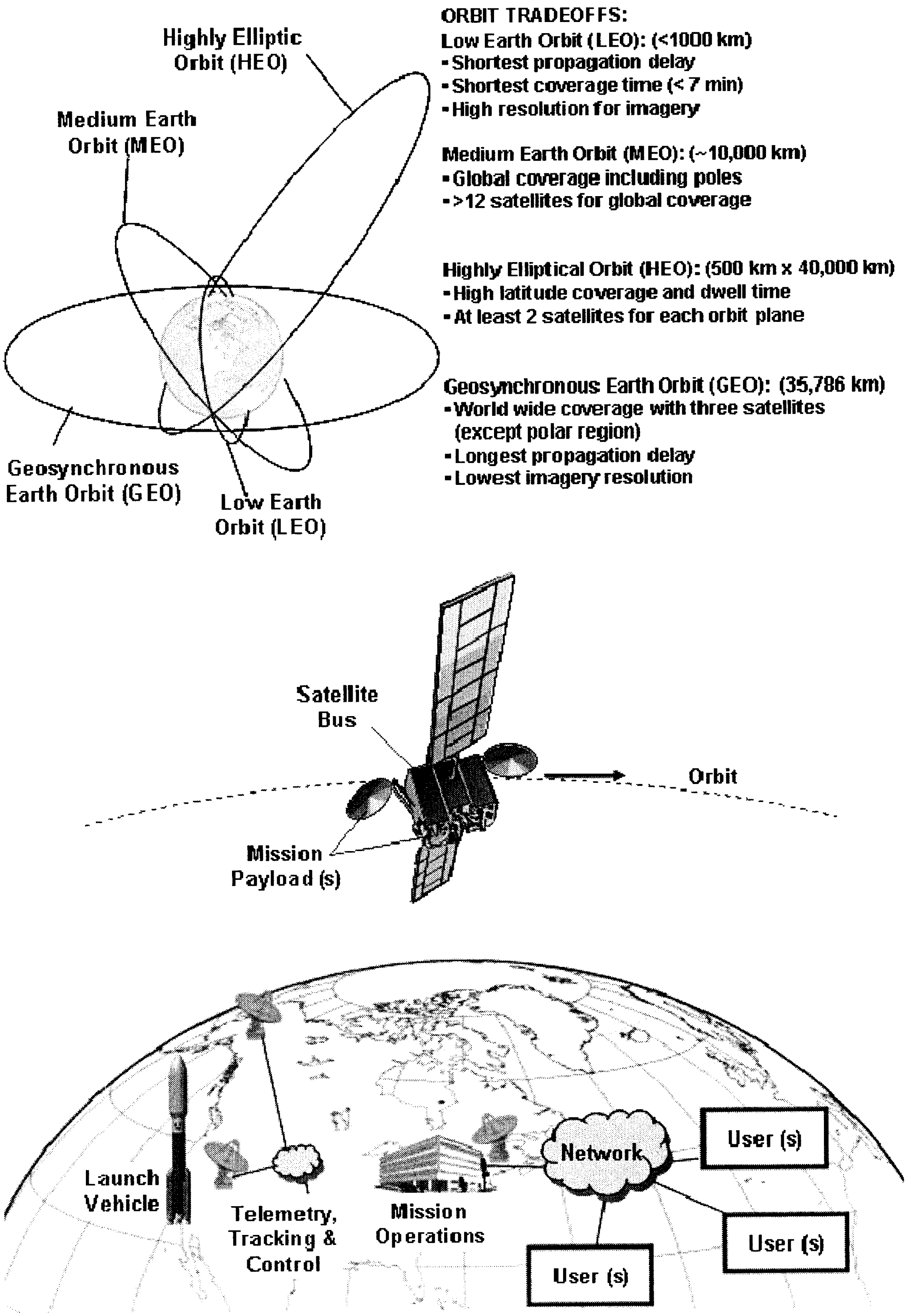

Figure 2-1 Satellite Architecture Overview

The payload may be provided by the prime contractor, a major teammate, or may also be Government Furnished Equipment (GFE). GFE is separately procured by the government, and supplied to the prime contract for integration on the satellite bus.

The ground system is the second major segment and often has two key elements: Telemetry, Tracking and Control (TT&C) and Mission Operations. TT&C provides basic health monitoring and support to the mission. Mission Operations provides overall control of mission functions, and user access to the system. Users ultimately gain access to the satellite for data products (i.e. weather images) or direct use of communication services.

2. 2 U.S. Government Satellite Market

Market Overview

Demand for U.S. Government satellites is a single customer monopsony supplied by an oligopoly prime contractor industrial base. Since the government issues requirements for unique national mission needs and is willing to pay the entire development and production costs, there is no other market for the specifically produced satellite system. Since monopsony is analogous to monopoly, but on the demand side, an implication is the buyer has enormous purchasing power and has the ability to reduce the price of the good near the cost of production (Noll 2005). On the supply side, significant consolidation in the aerospace industrial base has occurred creating an oligopoly as shown in Figure 2.2

Demand

The U.S. DoD space budget (classified and unclassified) DOD space budget of $19.4 billion for FY2003, $20 billion for FY2004, $19.8 billion for FY2005, and a request of $22.5 billion for FY2006[3]. NOAA is part of the U.S. Department of Commerce (DoC). Satellites are the single biggest budget item in the U.S. Department of Commerce's Budget in 2005 $722M plus an additional contribution by the USAF of $306M for the NPOESS system. NASA's budget for 2005 was $16.2B of which approximately $1.5B was for earth science[4].

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[3] U.S. Military Space Programs: An Overview of Appropriations and Current Issues, Congressional Research Service, August 7, 2006

[4] NASA FY 2005 Budget, Sean O'Keefe February 3, 2004

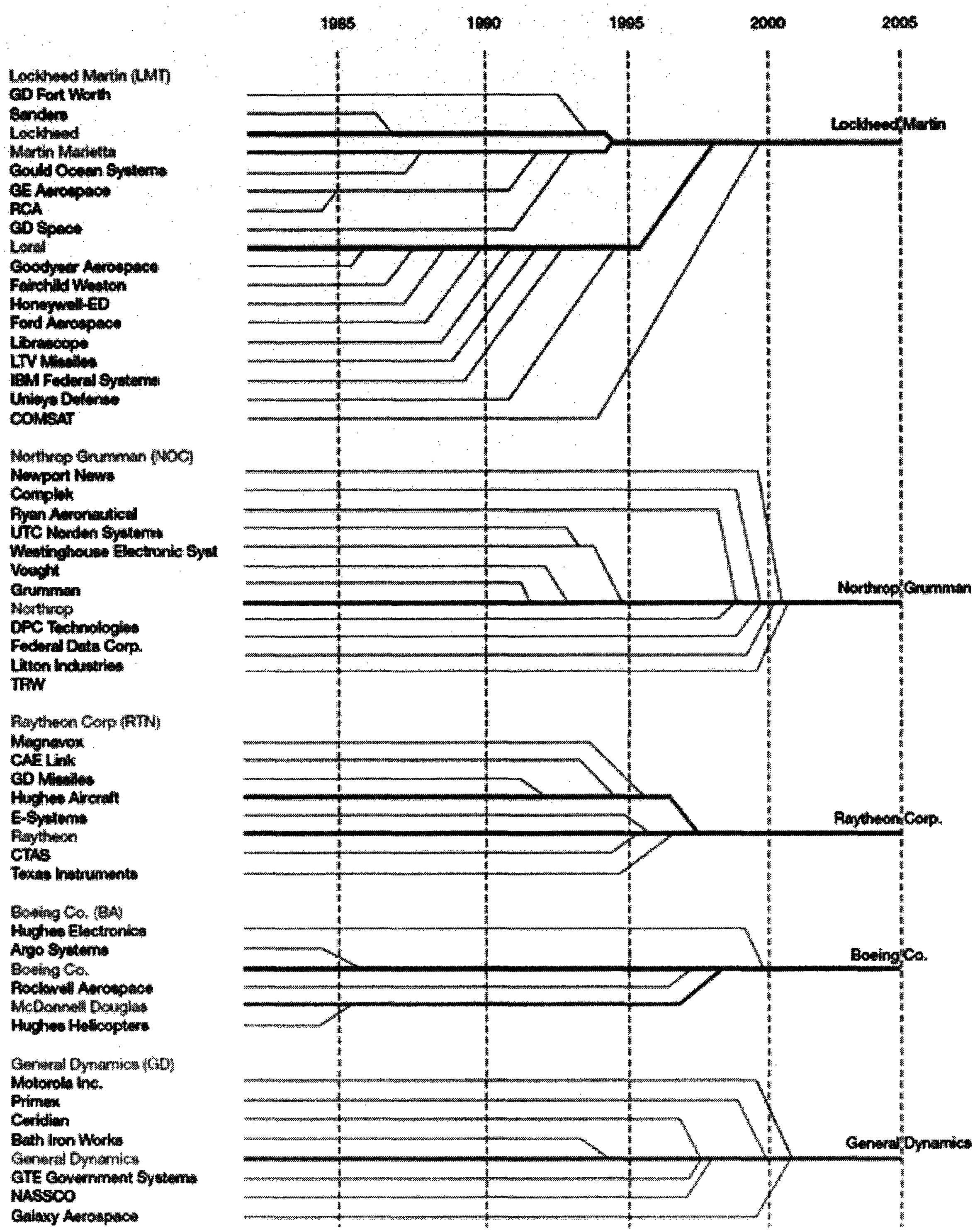

Figure 2-2 Aerospace and Defense Consolidation (1985-2002) – Source: Price Waterhouse Coopers (2005)

Supply

The market for U.S. Government satellite prime contractors has become an oligopoly. At the end of the Cold War, consolidation in aerospace and defense industry was initiated in 1993 at a now famous dinner held at the white house by the DoD Secretary of Defense Secretary Les Aspin. At a dinner, referred as "the last supper" (Augustine 2006), the top 15 defense executives were told the DoD procurement budget was to be greatly reduced and could no longer support the industrial base without consolidation. Initiated by the Secretary of Defense coupled with the Clinton administration allowing reimbursement of consolidation costs caused a flurry of consolidation in just a few years. Major consolidation ended in 1998 when DoD and DoJ denied the merger between Lockheed Martin and Northup Grumman (Shughart 1998).

Teaming

Government contracting has a unique relationship amongst contractors that usually not experienced in the commercial market. Prime contractors will routinely team with rival prime contractors or major suppliers to pursue individual contracts. These same contractors may also be direct competitors for other contracts with the same customer. This teaming tends to concentrate the market supply to a duopoly. Although rarely exercised, the government has the power to break teaming relations if it feels there is insufficient competition. In some situations, the government will ask industry to create a "National Team" to mitigate schedule delay of a full and open competition or preserve industrial base. This essentially creates a monopoly for a unique a particular mission. Teaming relationships tend to stay constant with incumbents for follow on competitions. This reinforces the incumbent organization inertia against adapting to the new architectural requirements.

2.3 U.S. Government Satellite Acquisition Process

U.S. Government acquisition rules are delineated in U.S. law, regulations, and agency policies and procedures. Title 41 (Public Contracts) of the U.S. Code delineates requirements for government product and service contracting. The Competition in Contracting Act of 1984 established under Title 41 states: *"shall obtain full and open competition through the use of competitive procedures in accordance with the requirements of this subchapter and the Federal Acquisition Regulation (FAR)[5]."* The Federal Acquisition Regulation (FAR), which became effective April 1, 1984 replaced the Defense Acquisition Regulations (DAR), the NASA Procurements Regulation, and the Federal Procurement Regulations (FPR). Each agency may tailor the FAR (i.e. DFARS or Defense FARS) to suit their specific agency needs. Acquisition policies are developed under the governance of the FAR to provide ground rules and guidance for major acquisitions. Acquisitions follow an extensive and well-established process. Figure 2.3 provides a typical source selection flow (DoE 2005).

Follow on Acquisition Choices

For follow-on award, a customer has two basic paths; sole source to the incumbent or full and open competition.

Sole Source

The Competition in Contracting Act of 1984 explicitly states that the federal government "shall obtain full and open competition through use of the competitive procedures in accordance with the requirements of this title and the Federal Acquisition Regulation."

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[5] *Title 41 > Chapter 4 > Subchapter IV > § 253*

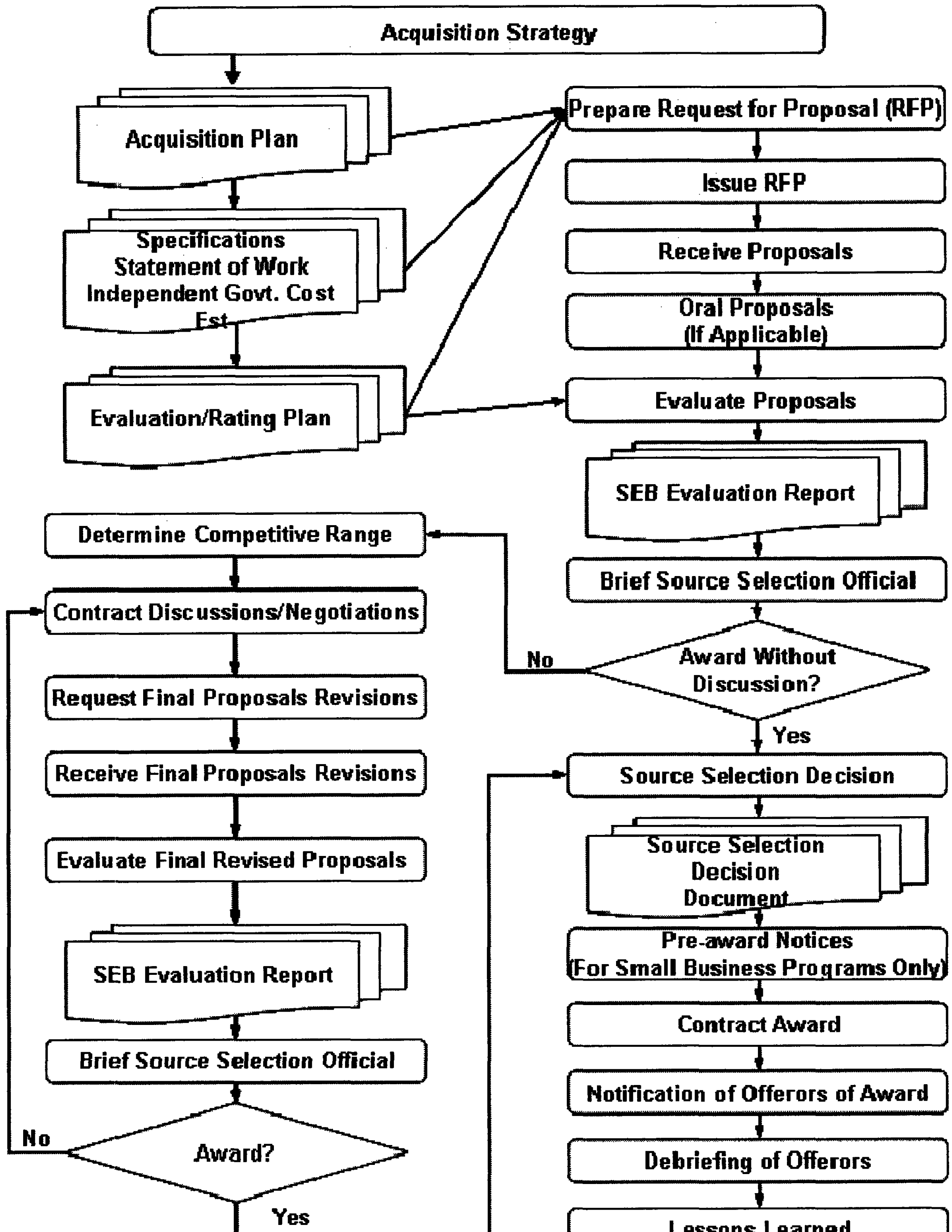

Figure 2-3 Typical Federal Government Acquisition Process

However, sole source contracts are an exception based on critical national need. The specific exceptions are: Only One Responsible Source, Unusual and Compelling Urgency, Industrial Mobilization, Engineering Development or Research Capability, International Agreement, Authorized or Required by Statute, National Security, or Public Interest. FAR 6.303 - *Circumstances permitting other than full and open competition* specifies processing of a Justification for Other Than Full and Open Competition (JOFOC). DoD and NASA contract value greater then $78.5M (2006) requires final approval by the agencies' senior procurement executive. The negative aspect of sole source is the continuation of a monopolist relationship, which entices premium pricing (Agapos and Dunlap, 1970) and lower innovation (Reinganum, 1983). Even though the JOFOC is publicly available, sole-source has the potential for abuse by acquisition officials and contractors improperly awarding contracts. One of the most notable cases was by Darleen Druyun - former principal deputy assistant secretary of the Air Force for acquisition and management - who plead guilty for conspiracy to violate Title 18 US Code Section 208(a), Acts Affecting a Personal Financial Interest and sentenced to nine months in federal prison. In sole source negotiations with Boeing concerning the lease agreement for 100 Boeing KC 767A tanker aircraft, Mrs. Druyun agreed to a higher price for the aircraft than she believed was "parting gift to Boeing", her future employer. [6] The Congressional Research Service estimated a premium of $5.5B for the arrangement versus a straight purchase[7].

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[6] UNITED STATES OF AMERICA vs .DARLEEN A. DRUYUN, April 20, 2004 plea agreement

[7] Observations on DoD KC-767 Lease vs Buy Scenarios Christopher Bolkcom and Ronald O'Rourke October 1, 2003 7 pages Congressional Research Service.

Full and Open Competition

Full and open competition is the primary objective of the U.S. Government, and sole-source awards will continue to receive enormous scrutiny. Henry Waxman, chairman of the House Oversight and Government Reform Committee, on January 4th, 2007 stated:

> *"We need more competitions, not less. And we need to place the interest of the taxpayers ahead of the interest of the contractors."*

Additionally, competition has the potential of bringing greater innovation and lower prices. However, it also brings new development risks and potential pitfalls of cost overruns, and schedule delays. A congressional review of the DSB (Young) report highlighted: "... *(the Young panel) was not convinced of the merits of competition in some circumstances, particularly when the incumbent has performed well and "owns" the expertise and the government would incur significant cost in choosing another contractor for follow-on systems."* GAO responded to this perspective on the merits of space program competitions stating: *"Competition can provide natural incentives for an organization to be more efficient and more innovative. These incentives work in DOD's favor."* [8]

Request for Proposal (RFP)

U.S. Government contracts have distinct differences to other industry studies of incumbent's failings. The primary difference is that contractors are awarded based on proposal against a set of requirements delineated in a government Request for Proposal (RFP) as opposed

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[8] January 29, 2004 The Honorable Wayne Allard Chairman The Honorable Bill Nelson Ranking Minority Member Subcommittee on Strategic Forces Committee on Armed Services United States Senate Subject: Defense Acquisitions: Risks Posed by DOD's New Space Systems Acquisition Policy GAO-04-379R DOD Space Acquisition Policy

to a commercially established product. The U.S. Government conducts full and open competition using a RFP based process regulated by the FAR. The RFP identifies at a minimum the desired product or service, specifications, and selection criterion. Numerous influences lead up to the RFP release often called "RFP shaping" though a combination of government and industry interactions. In the end, the contract is awarded against the final RFP. The customer may take several months to evaluate large proposals. Often a series of formal exchanges may occur during evaluation though Evaluation Notices (ENs). ENs allow the contractor to provide additional response for clarification or may also allow correction for a deficiency. Following selection, a contract negotiation may occur to refine the terms and conditions of the program. Losing contractors have the right to protest which the General Accountability Office (GAO) adjudicates. Any deviations from the FAR are strictly reviewed, controlled, and disclosed prior to final proposal submittal. Although anecdotal perceptions of factors outside the RFP influence award, numerous interviews confirmed the RFP is the final criteria for selection. One senior acquisition official cited:

> *"I've never seen an award not fully consistent with the RFP. If it's not in the RFP we cant consider it"*

Proposal Cost Estimating & Evaluation

Poor cost estimating is common with large projects accorss several industries (see appendix B) and not uniquely a challenge within DoD or government space programs. In testimony (GAO-05-570R), Robert E. Levin, Director, Acquisition and Sourcing Management for the GAO stated:

> *"Our own studies as well as other DOD studies have found that unrealistic estimates are common among all weapon systems, not just space systems, and that*

low estimates help ensure that the program will win support over competing programs and be funded"

Contractors have incentive to come in with low estimates to make their bids more competitive, and agencies have incentive to produce low estimates to make the programs appealing to budget reviewers and the Congress.[9]

Cost Estimating Methods

The method to cost estimating provides insight into the difficulty of predicting large complex projects but also how cognitive bias of incumbents and non incumbents may provide significant differentiation. Cost estimates are accomplished using a combination of parametric, analogous, engineering estimate, and actual cost approaches.[10] Parametric technique uses regression or other statistical methods to develop Cost Estimating Relationships (CERs). A CER is an equation used to estimate a given cost element using an established relationship with one or more independent variables. The relationship may be a simple ratio or may involve a complex regression analysis. The analogy technique estimates costs based on historical data for an analogous product or process. The cost of the proposed system is then adjusted with scaling factors based on differences such as performance, technology, and/or complexity. Adjustments may be made on quantitative data but may be based on judgments. Engineering Estimates are often discouraged because they have the most subjectivity. The technique draws on skilled expertise and may draw correlations to previous experiences. The "Actuals" technique uses actual cost data from experience and/or products that are used in the offering. When new

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[9] U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON SCIENCE HEARING CHARTER GAO Report on NOAA's Weather Satellite Program September 29, 2006 pages 1-7 pg 4

[10] Defense Acquisition Guidebook http://akss.dau.mil/dag/DoD5000.asp?view=document&rf=Guidebook/IG_c3.7.3.asp April 1, 2007

architectures are desired for follow on systems, the ability to use actual (or existing products) is reduced do to many factors including obsolescence, inferiority, or non-applicability.

Best Value Evaluation

"*... I know it when I see it . . .* "

- U.S. Supreme Court Justice Potter Stewart

Best value is inherently a subjective term; FAR Subpart 2.1 provides an official definition- *"Best value" means the expected outcome of an acquisition that, in the Government's estimation, provides the greatest overall benefit in response to the requirement.* The FAR permits Best Value selection over a continuum in which the relative importance of cost may vary. Two distinct methods identified are the tradeoff process and lowest price technically acceptable. All space acquisitions studied in this thesis used the tradeoff process. This process allows criteria other then cost to be deciding factor, such as performance, if it is deemed in the best interest i.e. value to the government. The predominant evaluation factors for acquisition selection are typically mission capability, proposal risk, cost/price, and past performance (Slate, 2004). Mission capability may be composed of any combination of subfactors, though typically include technical performance and management capabilities. Although cost overruns have put a "spot light" on low cost bids due to significant cost overruns, cost is typically the lowest evaluation criteria. The NASA GSFC GOES-R RFP provides an example:

Section M.4 EVALUATION OF PROPOSALS

(a) Offerors will be evaluated based on the evaluation factors listed below. Factors 1, 2, and 3 are further subdivided into subfactors, as explained in paragraph (b) below. Factors 1, 2, and 3 are of equal importance and each is more important than price ....

Factor 1—Mission Capability
Factor 2—Proposal Risk
Factor 3—Past Performance

Factor 4—Price.

(b) Within Factor 1—Mission Capability, there are four subfactors (listed below) which will be evaluated separately. These subfactors will also be used to evaluate Factor 2—Proposal Risk and Factor 3—Past Performance. Subfactor 2 is the most important subfactor; the other three subfactors are of equal importance.

Subfactor 1—Architectural Concepts
Subfactor 2—Program Definition and Risk Reduction
Subfactor 3—Risk Mitigation
Subfactor 4—System Engineering and Program Execution

Although not provided in the RFP, a graphical depiction shown in Figure 2.4 provides a possible

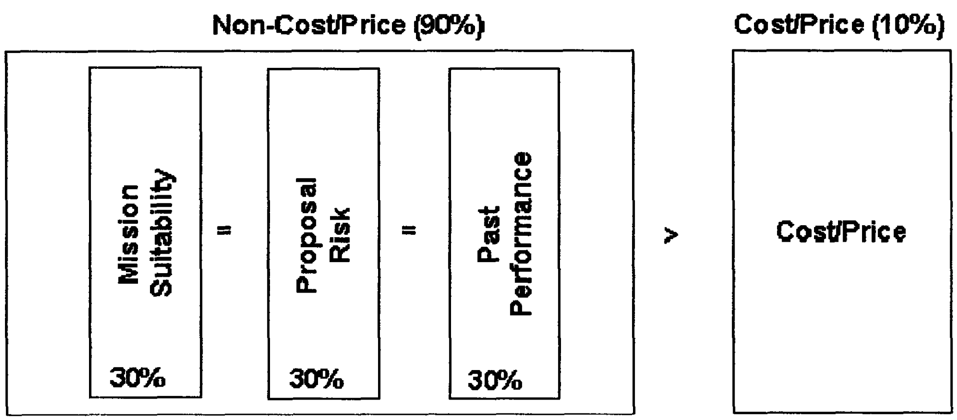


Figure 2-4 Notional best value relative weighting

relative weighting of each criteria.

However, customers rarely assign quantitative weightings. As a senior acquisition official commented:

> *"Some people try to do a formula, but then you have to live to it. Keeping it subjective gives you flexibility"*

.

Another acquisition official when asked if they use a formula responded:

"No. I have, but then you are stuck with that formula. Your fair, but you don't want to constrict yourself"

Emphasis on non-cost/price factors has increased; however, best value has always allowed government agencies to procure other then lowest cost. An offeror's evaluated costs may be adjusted higher by the government to a "should cost" based on factors such as deficiencies, proposal risk or past performance on delivering similar items. If negotiations occur, final costs may be adjusted to reflect some or all of the should costs. If negotiations are not conducted, then the award is to the offerors proposed cost, and the customer accepts a cost risk at the outset.

Best Value GAO Study

Limited study of best value awards is publicly available. However, the GAO released a study in April 14, 1999 for full and open, best value contracts awarded in fiscal years 1996 and 1997. Contracts greater than $500,000 from 37 buying organizations including; the Army, the Navy, and the Air Force; the departments of Agriculture, Commerce, Energy, Health and Human Services, Justice, Transportation, and Veterans Affairs; the General Services Administration, the National Aeronautics and Space Administration, and the Social Security Administration. Of the 250 best value contracts reviewed, only 53 were awarded to the higher bidder. Of those awarded to a higher bidder, the average premium was 7 percent. Further studies are required over a longer period; however, an award rate of 79% to the lower bidder in a best value competition likely reinforces contractor behavior.

3. Research Question & Literature Review

Those who do not remember history are condemned to repeat it.
- George Santayana

Research Question

This thesis attempts to explain a significant puzzle found in government competitions for satellites – the 90% rate of incumbent failure. According to most government studies, the cause of this failure lies in the willingness and ability of non-incumbent contractors to offer a lower priced contract. The accepted wisdom argues that non-incumbents are "not burdened" with previous program experience and are more optimistic in their bid price. The large number of schedule overruns found after competitions support this cause.

Such "buying in" is not a new contracting phenomenon for large public contracts (see Appendix B). However, despite efforts to reduce the emphasis on price – for example by using "Best Value" evaluations allowing a higher price if other factors such as performance or experience provide higher value to the government - has not changed the fate of incumbents. The academic literature provides several alternative explanations for incumbent failure, specifically a better focus on the customer, more organizational capacity for novel designs (etc. etc.). This thesis seeks to explore whether these alternative perspectives provide more insight into the incumbent-non incumbent dynamics in satellite competitions and degree to which these organizational factors are salient in driving the outcome of satellite competitions. In other words, if costing were to be equalized, would incumbents win more often frequently or do they suffer from other disadvantages.

Literature Review

A review of the academic literaiture on incumbent-entrant dynamics provides four distinct dimensions along which incumbents and entrants can be distinguished; ability to manage customers through periods of disruptive innovation (Christensen 1997), inability to predict and react to S-Curves and Discontinuties (Foster 1986 , Utterbach 1994), challenges in balancing Product/process evolution (Utterback 1996), aptitude for architecture innovation (Henderson and Clark 1990).

Disruptive Innovation

Disruptive Innovation (Christensen 1997) refers to a new technology having lower cost and performance by traditional standards, but having higher ancillary performance as shown in figure 3-1. Christensen's study of the computer disc drive industry illustrates how companies with established products fail to see competing products with lower traditional performance such as memory capacity for laptops, erode the established market leaders buy attacking with ancillary performance such as size, weight, and ruggedness.

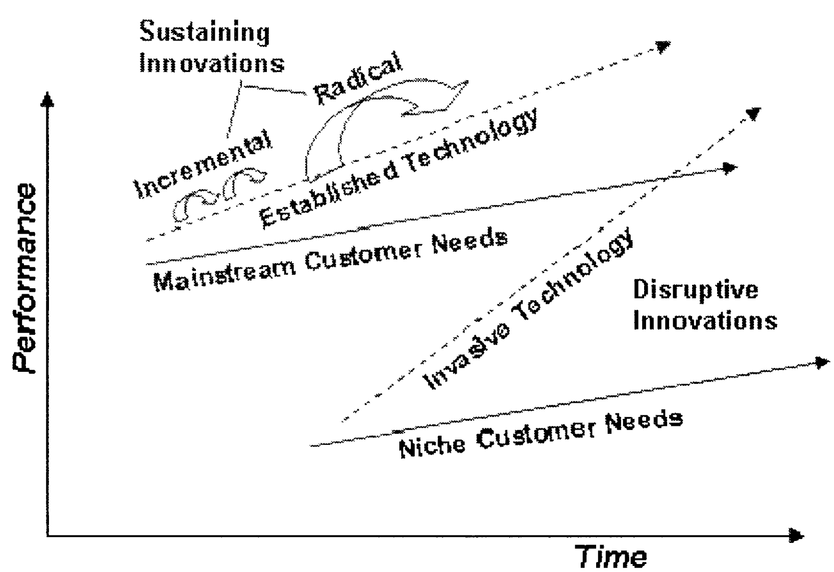


Figure 3-1 Disruptive and Sustaining Innovation

The satellite programs studied herein falls into sustaining technology category versus disruptive innovation. That is they offer increasingly incremental or radical innovation improvements in traditional performance such as communication capacity versus “smallsats” (<500 kg). Christensen would comment that incumbents “almost nearly win” along a sustaining technology path. However, this has not been the case with government satellite competitions, which requires an expanded theory.

An important aspect of Christensen’s theory is that organizations focusing all attention on the existing core customer often fail to see value or credibility in non-incumbent innovations.

Technology Evolution and Discontinuos Innovation

As technology matures and incremental performance improvements become smaller (Foster 1986), a disparity develops between growing user need and diminishing technology performance improvements. As new technology innovation enters the market a disconiutity develops from the incumbent technology and the new technology. The incumbent technology producers typically respond with a burst of improvement (Utterback 1996) to counter the threat from the invading technology as shown in Figure 3.2. Innovation is focused on incremental low risk improvements rather then higher risk radical innovations. With high return on investment, incumbents have reinforcing incentives to invest in older, low risk technology by leverage exisiting assetts and resources. The pattern is similar in satellite evolutionary aquisition (see Appendix D) or “block” upgrades allowing the incumbent to protect their technology for a short time longer. Eventually competition occurs and incumbents rairly make the transition. This theory adds to the explanation, but still does not provide a complete framework to the underlying phenomina.

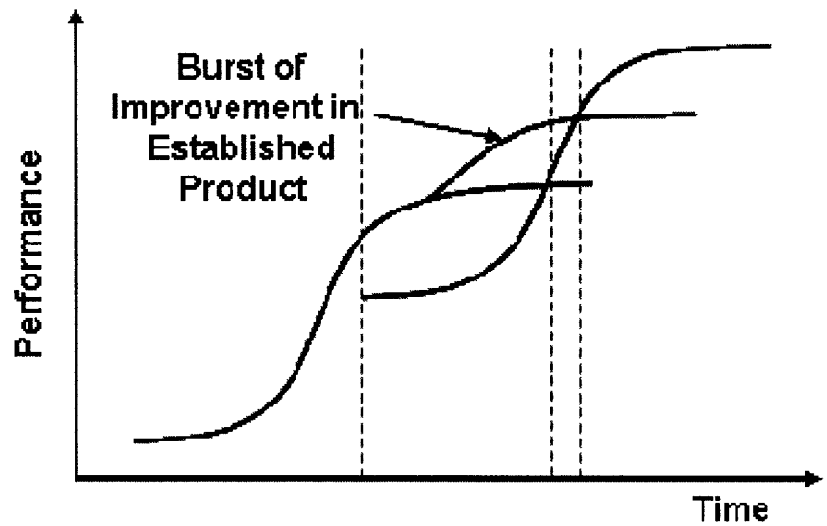


Figure 3-2 Performance of an Established and an Invading Product; A Burst of Improvement in Established Product. (Utterback, 1994)

Dominant Design and Process vs Product Innovation

A dominant design (Utterback 1996) can be characterized when a design standard is reached and innovation transitions from a product to process focus. At this point, product innovation is shifts radical to incremental innovation. The corresponding dominant design establishment in satellite development is the Critical Design Review (CDR) as shown in figure 3.3. CDR finalizes the satellite design and initiates the production phase. Prior to CDR, the majority of engineers are system and design engineers, with a smaller focus on process and production engineering. A significant shift in skill mix occurs after CDR with a reduction in design and system engineers, and an increase in production, assembly, integration and test personnel. The organization shifts from product innovation to process innovation as well. If the incumbent leverages existing resources at the time of follow on competitions, they may draw on the wrong skill mix. A non-incumbent is un-burdened by a previous solution, and is free to create an organization to optimally respond to the competition. This theory also adds to the explanation, but does not proved a complete explanation

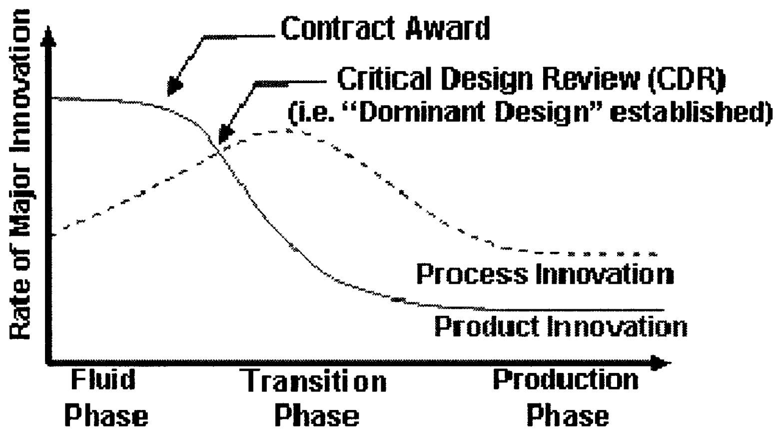


Figure 3-3 Dominant Design and shift from product to process innovation (Utterback 1994)

Architectural Innovation

Architectural innovation provides the strongest explanation of follow-on satellite performance improvement. Architecture innovation is the reconfiguration of components in a new way providing radical performance improvement (Henderson and Clark, 1990). Components are defined as a distinct portion of the product that embodies a core design concept and performs a well-defined function such as a motor in a fan. Components may be viewed as parts, or higher levels of assembly that constitute a core-distinct function in the overall architecture as characterized in figure 3.4. New component technology may spark the re-architecture but often-existing component technologies are reconfigured with addition of a few new component technologies (Henderson and Clark, 1990).

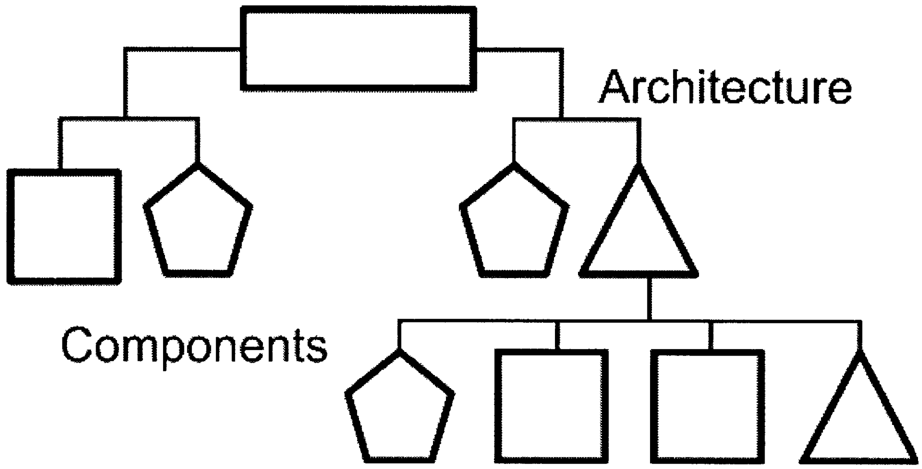


Figure 3-4 Architecture and component representation

Incumbent firms have a tendency to lead incremental improvements in components as they reinforce established core organizational competantcies and capabilities (Abernathy and Utterback 1978). Non-incumbents have a tendency to lead new architectures. They are unburdened from any pre-embedded architecural solution and are free to make architectural changes and trade-offs to create radical performance improvements as noted by Henderson and Clark (1990):

> *"...architectural innovations destroy the usefulness of the architectural knowledge of established firms, and that since architectural knowledge tends to become embedded in the structure and information-processing procedures of established organizations, this destruction is difficult for firms to recognize and hard to correct."*

Depending on the scope of satellite procurement, analogous component levels may correspond to subsystems, payloads or the satellite itself in a larger architecture. An explanation of managent resistence or support to architecture innovation is revealed by looking at organization structures. Christensen and Kaufman (2006) highlight the four basic teams shown in figure 3-5 identifed by Wheelwright & Clark (1992).

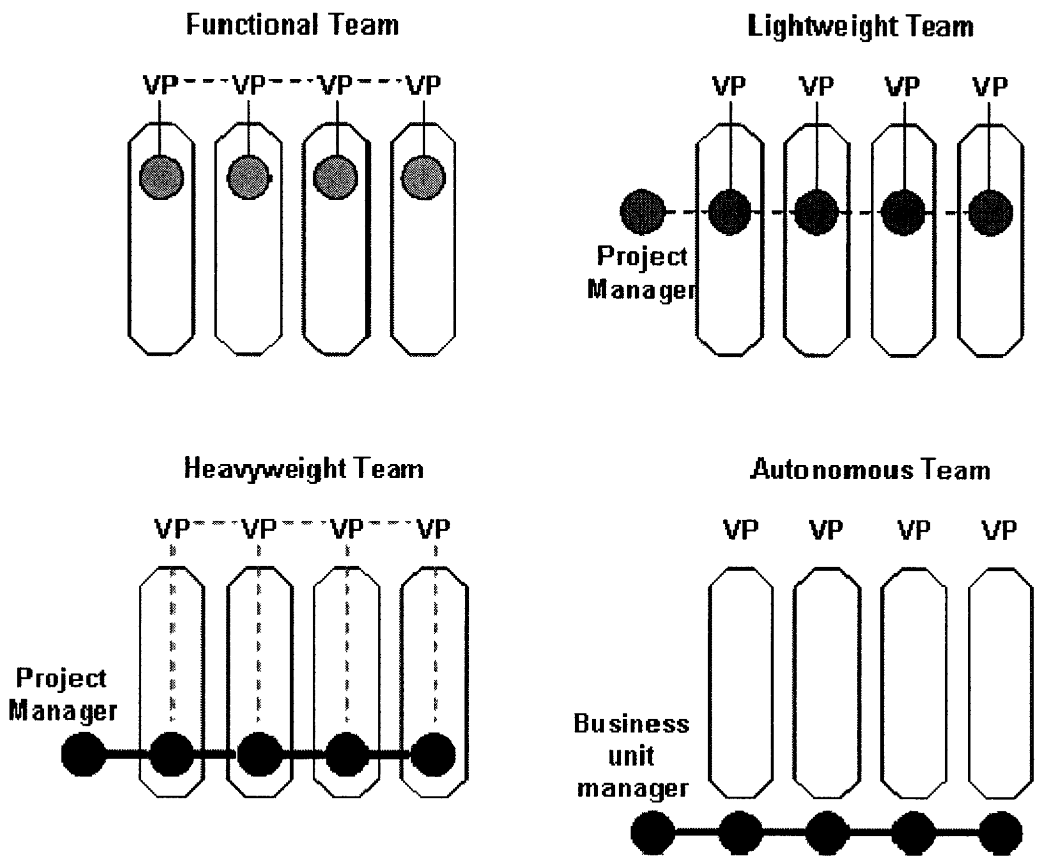


Figure 3-5 Four basic team structures (Wheelwright & Clark, 1992).

In figure 3-6, Christensen and Kaufman highlight how each of these teams is best suited for different innovation advancements. Functional and lightweight teams are are ideally suited for incremental innovations within an established architecture where interfaces are well defined and expertiese is developed around components. They exploit established business capabilities, processes and investments. For radical innovations, a heavyweight team is required and for disruptive innovation a heavyweight or autonomous team is required. These teams have the organizational freedom to canibalize existing core competancies and capabilities.

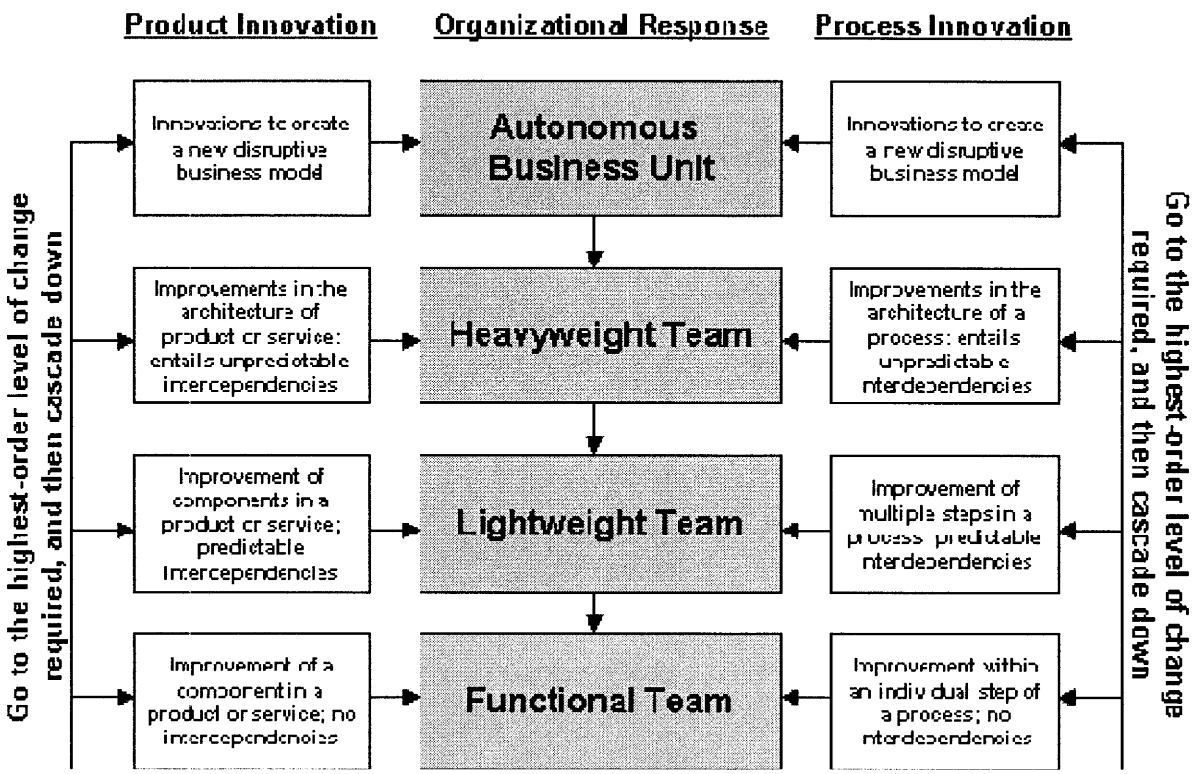


Figure 3-6 Framework for Organizational Design (Christensen and Kaufman, 2006)

As architectures mature, organizations default to lower cost functional organizations. Heavyweight and autonomous teams are inherently more costly due to skill levels, incentive structures and lower expectations on return on investment. Therefore, the incumbent organization defaults to a functional organization and as Henderson (1990) identifies the architecture becomes embedded in the organization. Since non-incumbents have no organizationally embedded architecture, heavyweight teams have the flexibility to optimize the architecture with no pre-conceived solution.

Organization Visioning

Organization behavior has a profound effect on business behavior. How an organization reacts to changing business conditions and new business prospects, will impact how it directs its resources. This section looks how incumbent and non-incumbent organization look see follow-on compeitions and the frameworks they employ to react to follow-on competitions.

Categorization Theory: Threat vs opportunity

> *"A pessimist sees the difficulty in every opportunity; an optimist sees the opportunity in every difficulty".*
>
> *- Winston Churchill*

Where some see threats others see opportunities. In my interviews and experience, it is common for incumbents to identify follow on compeitions as a "threat" and new entrants to identify follow on competitions as an "opportunity." Dutton and Jackson (1987) studied the effect of how organizations identified new projects has an organization impact on reacting to the new project. Their most compelling hypothesis is how organizations respond to issues when decision makers label issues either threat or opportunity:

> *"When decision makers label issues as opportunites, involvement in the process of resolving the issues will be greater and participation will take place at lower levels of the organization, compared to when issues are labeled as threats."*

Threat may be a perfectly valid label particullarly where strong command and control discipline is required. For example, emergency operations where little time is available and pre-determined emergency processes have been established. Although innovation is not discouraged, the overall value of clear and unambiguous direction is more valued. However, in pursing complex systems, architecture innovation requires unencumbered trade-off decisions throughout the organization.

Core Capabilities and Core Rigidities

Satellites and their associated architectures can be thought of as shaping a firm's core capabilities Industry officials often sight "protecting core" as a key strategy. However, this strategy contributes to the architectural rigidity. Leonard-Barton (1992) highlights the notion that core capabilities inhibit innovation and can become core rigidities. She identifies core capabilites as technical systems, skills, and mangment systems which all have deeply rooted values of the organization. These values make up a critical and often overlooked aspect of core capabilities and architectures.

Incumbent Inertia – First Mover Advantage

As core capabilities become core rigidities they create an incumbent inertia (Lieberman and Montgomery, 1998). The non-incumbent is often cited as having "first mover" advantage. Lieberman and Montgomery site several root causes of incumbent inertia. (1) The firm may be locked into a specific set of fixed assets, (2) the firm may be reluctant to cannibalize existing product lines, or (3) the firm may become organizationally inflexible. Additionally incumbent inertia may result from complacency, arrogance, or inattention to shifts in technology or customer needs. "It's ours to lose" and "they (the non-incumbent) can't possibly do this job" are frequent quotes from industry officials in recalling their inevitable loss to a non-incumbent. Incumbent arrogance of knowing more then the customer and their rigidity inhibits visioning beyond their current architecture and radical innovation.

Appoach

The literature provides a wealth of possible explanations for incumbent failure, with few theories tested in more than one or two empirical settings. It is therefore difficult to initiate this study with a clear set of hypotheses. Instead, the drivers of incumbent failure are examined using a mix of qualitative and quantitative evidence. The research approach is inductive – as shown in figure 3.6, it begins with observations of patterns, then formulation of tentative hypotheses or questions, which may begin broadly, then refined during the research, concluding with developing a theory (O'Leary 2004). A review of academic literature is studied to provide an academic foundation to the theory. Analyses of three case studies are reviewed against the theory. Interviews with industry and government officials provide additional depth and insight. This method was deemed most appropriate given the questions for several reasons: First, since most acquisition data is either proprietary or government source selection confidential, a pure deductive quantitative approach is not feasible. Second, this thesis is framed around an open examination of a phenomenon for which there may be several competing theories further precluding the appropriateness of hypothesis tests.

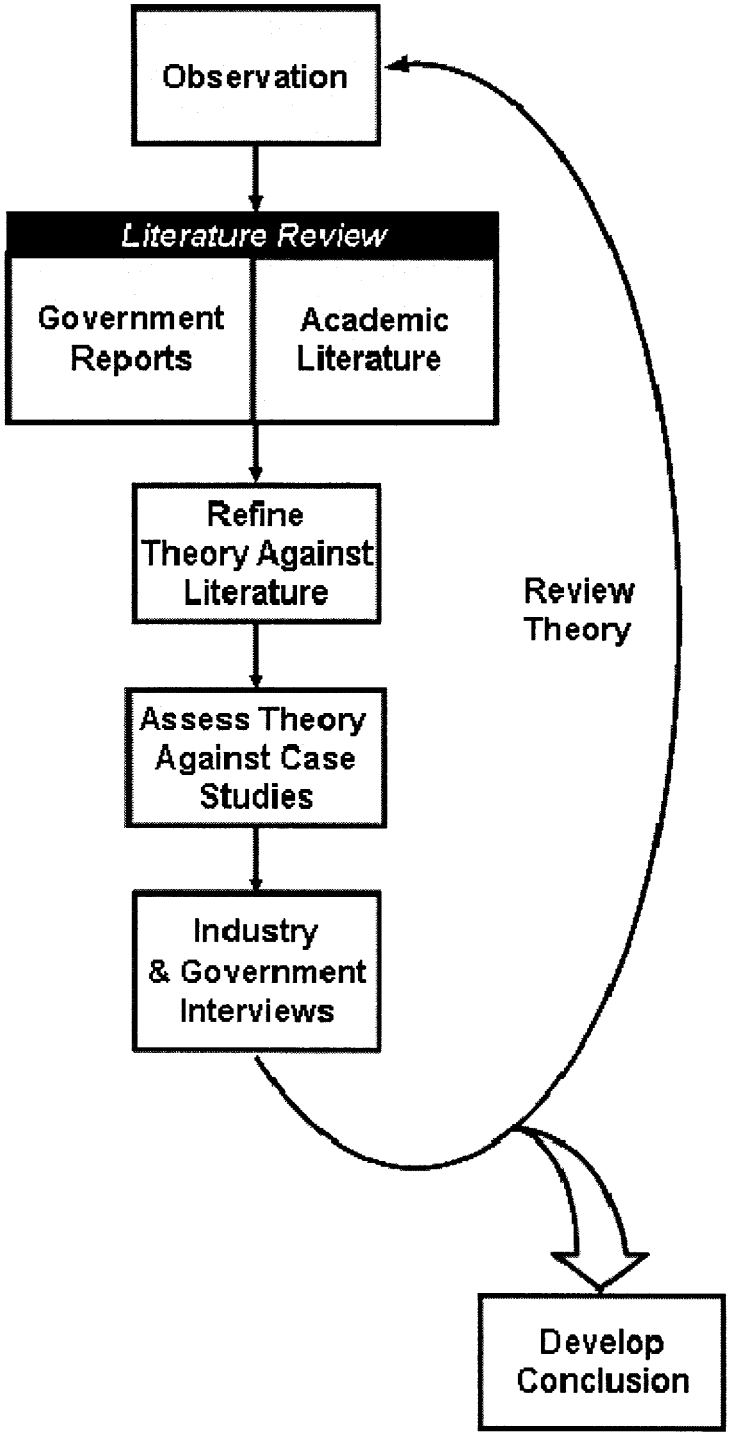


Figure 3-7 Research Process

4.0 Case Studies

Three case studies are used to test the notion that two factors – i) the challenges of architectural innovation and ii) the supporting organizational behaviors around these architectures - drive the failure of incumbents in satellite competitions. Incumbents loose in two of the three selected cases. The first case, EOS AM-1 to EOS Common, studies TRW unseating Lockheed Martin. The second case, UFO to MUOS, studies how Boeing (formerly Hughes) was unseated by a new system architecture developed by Lockheed Martin. The third case, LEASAT to UFO, studies how Hughes as the incumbent successfully won the follow-on UFO by changing its platform product line architecture. An important aspect to the two losing incumbent cases is their actual follow-on offer is not available due to source selection confidentiality. Only the incumbent program approach and the winner's solution can be studied in context to the change the customer ultimately chose.

4.1 NASA EOS Common Program

Program Overview

The Earth Observation System (EOS) is part of NASA's "Mission to Planet Earth" to provide long-term remote sensing observation for climate change observation and study. EOS is managed by NASA's Goddard Space Flight Center (GSFC). Its satellites are very complex carrying an array (6 to 12) of very sophisticated remote sensing instruments. NASA manages each sensor through separate contracts. The instruments are delivered as GFE to the prime satellite contractor for final integration and test before launch.

Incumbent and Heritage

General Electric Aerospace (GE) (formerly RCA Astro Space) in New Jersey was the incumbent having won the design for the EOS-AM-1 in 1986. EOS-AM-1 was later re-named EOS Terra (Greek for Earth) after launch. EOS-AM-1 design leveraged significant a structural technology heritage from a previous GE mission - the Upper Atmosphere Research Satellite (UARS) as shown in figure 4-1 – specifically the same composite truss and titanium node technology and bolt-on equipment modules.

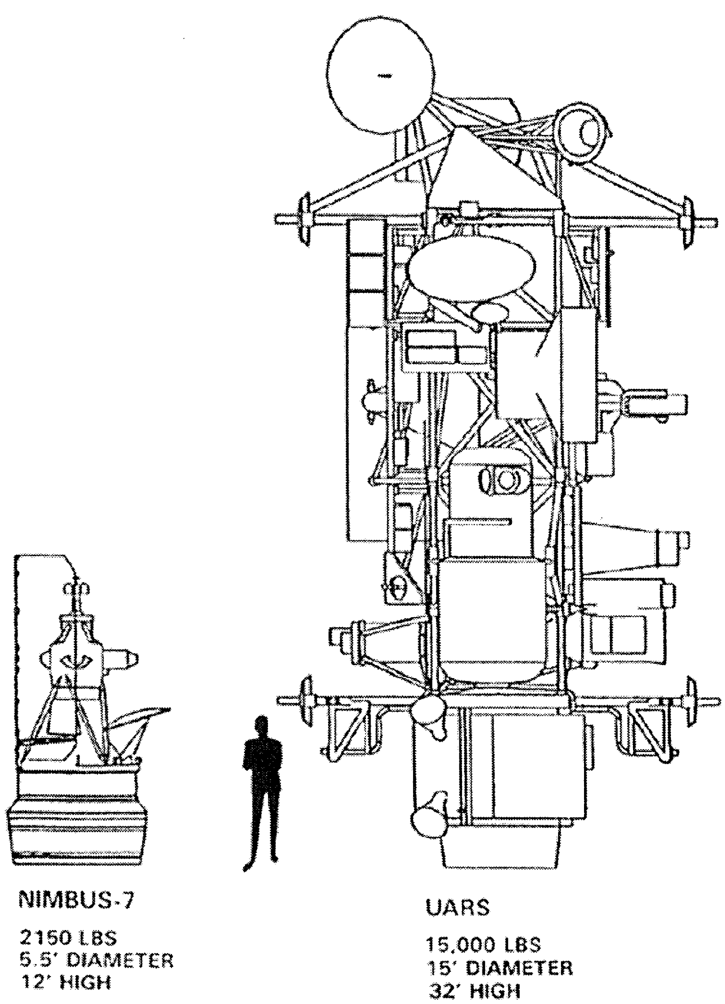


Figure 4-1 Nimbus and UARS Satellite Size Comparison

UARS was an enormous satellite weighing over 13,000 lbs with a length of 35 feet and diameter of 15 feet and was launched by the Space Shuttle in 1991[11]. Carrying 10 sophisticated instruments to monitor upper atmospheric phenomena contributing to climate change, UARS provided conclusive scientific evidence proving man made aerosols erode the protective ozone layer. Fitting in the Space Shuttle cargo bay connecting to the sides vs. on top of an expendable booster along with mission unique instruments drove a very complex composite truss structure connected with titanium nodes. The structure alone weighed 3,428 lbs. Leveraging this technical experience, GE designed the EOS AM-1 satellite with the same composite truss and titanium technology as shown in figure 4.2.

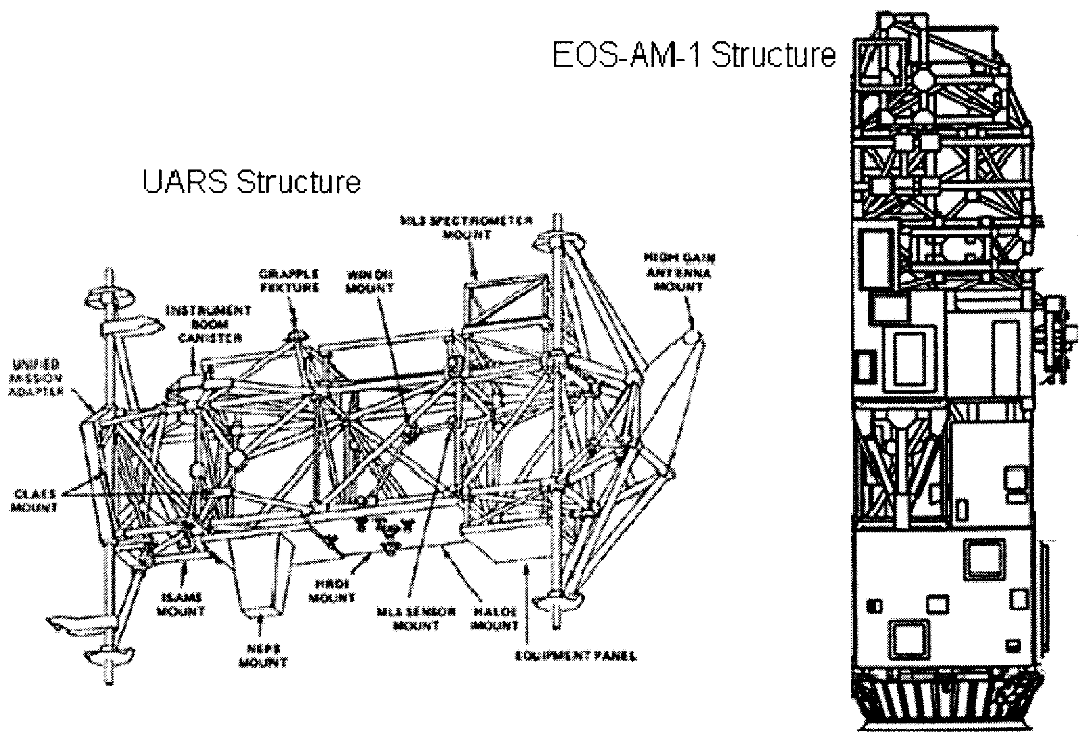


Figure 4-2 UARS and EOS-AM-1 Satellite Structures

- [11] NASA GSFC Fact Sheets http://www.gsfc.nasa.gov/gsfc/service/gallery/fact_sheets/earthsci/uars.htm January 1994

EOS AM-1 was originally manifested to launch on the space shuttle, which made this structure design a low risk and proven approach. With a Shuttle lifting capability of 35,000 lbs and large cargo bay, weight and volume are not driving constraints. With the Challenger Space Shuttle explosion in 1996, NASA began to shift non-human critical missions to expendable boosters. The primary driver for expendable boosters is weight and volume. Since EOS AM-1 retained the heavier structure design, this required EOS AM to be launched with a Atlas II, to accommodate the large satellite.

Customer Follow On Objectives

Larger satellites are more expensive also requiring larger, more expensive expendable booster to lift them to orbit. For the follow on missions, NASA GSFC had two primary objectives: 1) To develop a common platform (or "bus") to avoid expensive re-development of a satellite bus for each mission; 2) Launch the satellites on a smaller and less expensive Delta II launch vehicle versus the larger Atlas II launch vehicle. (~$60M vs. $100M)

Competitors

General Electric was incumbent for EOS AM-1. Both GE and RCA (with whom it merged in 1986) each dominated the earth resource satellite business since the first LEO weather satellite launch in 1960. With two divisions located within an hour drive of each other and only a three-hour drive from NASA GSFC. There existed a close working relationship between the government and the companies for over three decades on earth resource missions. Lockheed, TRW, and Hughes Space & Communications were the non-incumbent competitors. Each non-incumbent was an established satellite producer and all had performed various scientific missions for NASA GSFC. No competitor had built LEO earth resource mission with NASA GSFC.

Hughes had experience with the customer and accommodating remote sensing instruments by previously building geostationary spinning weather satellites for GSFC. TRW had extensive GSFC experience in LEO missions and sensor accommodation, but no prior LEO remote sensing. Lockheed had extensive remote sensing experience and was the final integrator and bus provider for the Hubble space telescope for NASA GSFC. Lockheed withdrew its offering after consolidation with the GE team.

Winning Solution

NASA selected TRW as the winner. The centerpiece to TRW's solution was an all-composite panel structure bolted together as shown in figure 4.3. This provided significant reduction in structure weight and volume. The TRW EOS Common Aura configuration carried 1,200 kg of instruments with and entire satellite weight of 2,967 kg (NASA) allowing a smaller, less expensive Delta II expendable booster. In comparison, EOS AM-1 carried 1,155 kg of similar class instruments with an entire satellite weight of 5,190 kg.

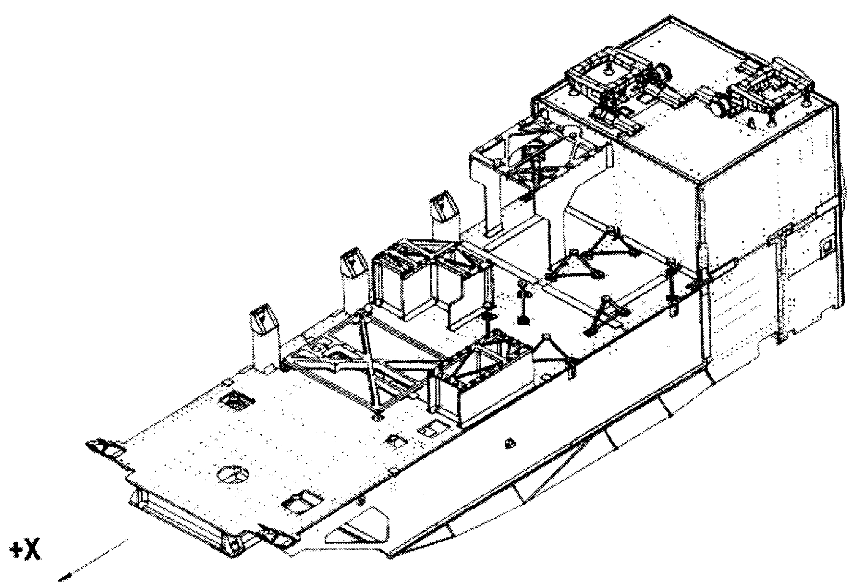


Figure 4-3 TRW EOS Common Satellite Structure

The predominate enabling difference is architectural configuration of structure component technology. Additionally, TRW provided an innovative business offering along with their lowest price. Hughes and Lockheed Martin filed a protest against the award. The GAO upheld the award decision to TRW. Even though Hughes had higher technical performance and an overall cost cap, the GAO agreed with NASA that the lower initial price was very attractive *"TRW would have to overrun $400M before hitting Hughes cost cap......"*

Conclusion

This case provides two interesting results. First, the incumbent lost with lower technical performance and higher price then the other competitors. Second, two of the three non-incumbents provided innovative higher performance and lower price offerings then the incumbent. TRW (later becoming Northrop Grumman) was able to leverage their common bus for the $4.5B NPOESS LEO weather mission.

4.2 U.S. Navy and UHF MILSATCOM (UFO to MUOS)

Program Overview

The Mobile User Objective System (MUOS) provides the U.S. DoD global secure mobile communications low rate data (<64 kbps) on the move. The U.S. Navy has procured every DoD UHF MILSATCOM system since the 1960s including LEASAT and UHF Follow on (UFO).

Incumbent

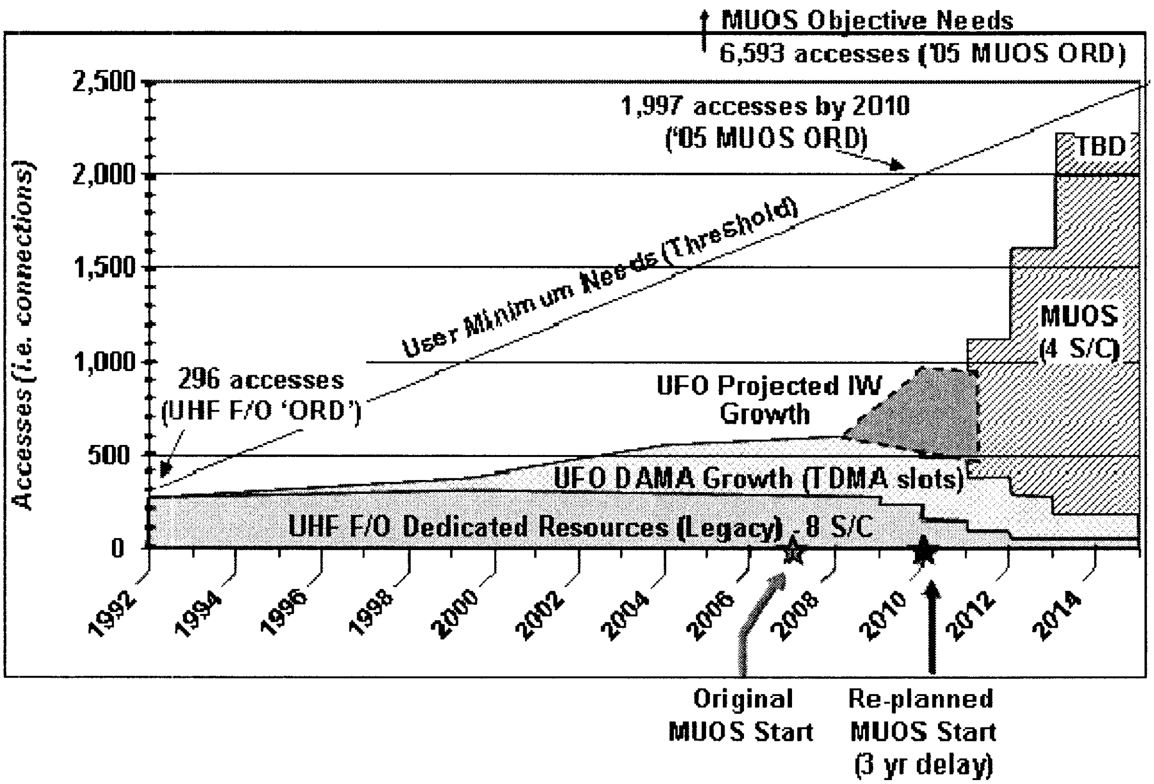
Boeing Space Systems (Formerly Hughes Space Systems) was the incumbent for the UHF Follow on System (UFO). UFO had been a model of innovation in the DoD. Hughes had leveraged their commercial communication satellite program and applied it to meet military specifications. They performed under a Firm Fixed Price (FFP) contract, and guaranteed delivery on orbit by purchasing insurance to replace the satellite in the event of launch failure. The contract relationship with the customer and their mutual performance won the program a Presidential "Hammer Award" from Vice President Al Gore. Hammer Awards, were a symbol of cutting waste and inefficiencies. The Hammer symbolism was based on acquisition inefficiencies costing the DoD in one famous instance spending $435 for a hammer. Hughes was also one of the rare contractors that had won the previous follow on contract through their innovative UFO offering as discussed in the second case. By all accounts, the incumbent had outstanding past performance and a record of innovation.

Incumbent Approach

Due to source selection sensitivity of the competition, Boeing's specific solution for MUOS is not known. However, Boeing publicly announced Viasat as a major teammate. Viasat's predominant business and technology base is the older incumbent technology, which is also a government unique standard. From this, one can surmise that Boeing was leveraging from their existing basis of technology and architecture.

Customer Follow On Objectives

The customers objective was to increase communication capacity by at least a factor of ten (i.e. >10X) as well as communicate with smaller "hand held" radios versus larger "man pack" radios. This is well beyond incremental innovation the previous system was able to implement, and required radical innovation. As shown in figure 4.4, the disparity between user need and the incumbent system's ability to meet those needs grew to unacceptable levels.



Source: Keith Hollinger, SMDC/ARSTRAT CIO/G6 MUOS SATCOM System Expert (SSE) Narrowband SATCOM Support – Current/Future August 23, 2006

Figure 4-4 UHF MILSATCOM requirements versus UFO and MUOS capability

Competitors

In the initial studies, the Navy pursued a wide range of alternatives including leasing commercial services, Unmanned Aerial Vehicles (UAVs), and dirigibles. All options for space architectures including orbits, and communication standards were open in the trade space. This brought a number of interested companies beyond traditional large satellite manufactures. When the architecture options were narrowed to large space based solutions, the tradition satellite manufacturers remained to pursue risk reduction contracts. The Navy issued two $40M, 14 month contracts to mature architecture designs and perform risk reduction suited to each contractor's architectures. Surprisingly, Boeing was the eliminated during this early phase. The Lockheed Martin/General Dynamics team along with the Raytheon/Loral team were selected for the risk reduction phase. Boeing then joined the Lockheed Martin/General Dynamics team. Spectrum Astro in Glendale AZ is a small (<1000 people) satellite manufacturer also deselected at this phase.

Winning Solution

Lockheed Martin won by providing an innovative architecture solution by applying commercial 3rd Generation (3G) commercial cellular communications to a military satellite architecture. This was a radical architecture shift from the previous UFO architecture.

Conclusion

Lockheed Martin provided an entirely new architecture. The previous architecture was a less-complex transposed system, in that the ground system was not a crucial component of the system operation. In contrast, MUOS architecture functionality is distributed through the satellite and ground system "components." The ground system has significant functionality to enable communications to the user. The application of 3G commercial technology reuses significant commercial hardware and software "components" but provides radical architecture performance improvement.

4.3 An incumbent Success - U.S. Navy and UHF MILSATCOM (LEASAT to UFO)

As highlighted in Table 1-1, it is a rare event that an incumbent wins a full and open government satellite competition. However, an important exception arose in 1988 when Hughes Space and Communication (Hughes), the incumbent won the USN UHF Follow on (UFO) competition with a novel satellite architecture innovation.

History of Hughes Communications Satellites

Hughes is one of the most successful communication satellite in the world. Having Launched the first Geosynchronous communications satellite Syncom 1 in 1963 and Syncom 2 in 1964 (Martin, 2000) established a long and successful history of communication satellites launching its 200th communication satellite by November 2001 (http://www.boeing.com/defense-space/space/bss/hsc_pressreleases/01_11_27_200.html)

With the launch of Syncom, Hughes also established a dominant platform design that specifically used the architecture of spin-stabilized satellites. This provided simplicity in attitude control by utilizing the spinning momentum of the satellite to create a stable pointing platform. With increasing capability in launch vehicles and greater demand for communications, Hughes was able to sustain the evolution of this architecture with increasingly larger spinning platforms and performance. However, the fundamental design constraint on spinning satellites is the launch vehicle fairing that protects the satellite during ascent through the atmosphere. The fairing internal diameter restricts the maximum diameter of the satellite cylinder as shown in figure 4-5. Solar cells mounted onto the outer surface of the cylinder convert solar energy to usable electricity to power the communication payload. The increasing demand for communication services, and thus the demand for increased power levels proved to be an architectural dilemma for Hughes. RCA and Ford had already developed fundamentally different architectures with three-axis stabilized platforms with deployable solar arrays. Three-axis stabilized satellites are more complex using internal momentum wheels and sophisticated control systems to provide stable pointing for the platform. Deployable arrays are more complex, introducing potential deployable failure modes as well as complex techniques required the solar arrays to track, collect, and transmit power to the power distribution system. However, once these technologies were demonstrated, a radical increase in power collection enabled by the ability to deploy large solar power collection surfaces.

The spin stabilized architecture limitations presented a fundamental decision for Hughes to change their satellite platform architecture. Developing a 3-axis platform architecture is a technology challenge unto itself. Changing architecture in an established organization is an even greater undertaking and is a rare event (Henderson 1990). Hughes certainly demonstrated characteristics of resisting this architecture change. Hughes initially countered with a significant sustaining evolution - a telescoping solar array cylinder over cylinder effectively doubling power (i.e. 1X) with their HS 376 platform used on over 50 satellites. They also developed the HS 381 "wide body" which leveraged the 14-foot diameter of the Space Shuttle. As Henderson highlights, the majority of component technology is the same such as power, command and telemetry, propulsion, etc. However, the re-architecture of that component technology requires a fundamental change in the organization. Despite presumed resistance, shifting to a new 3-axis satellite architecture was essential to Hughes market survivability.

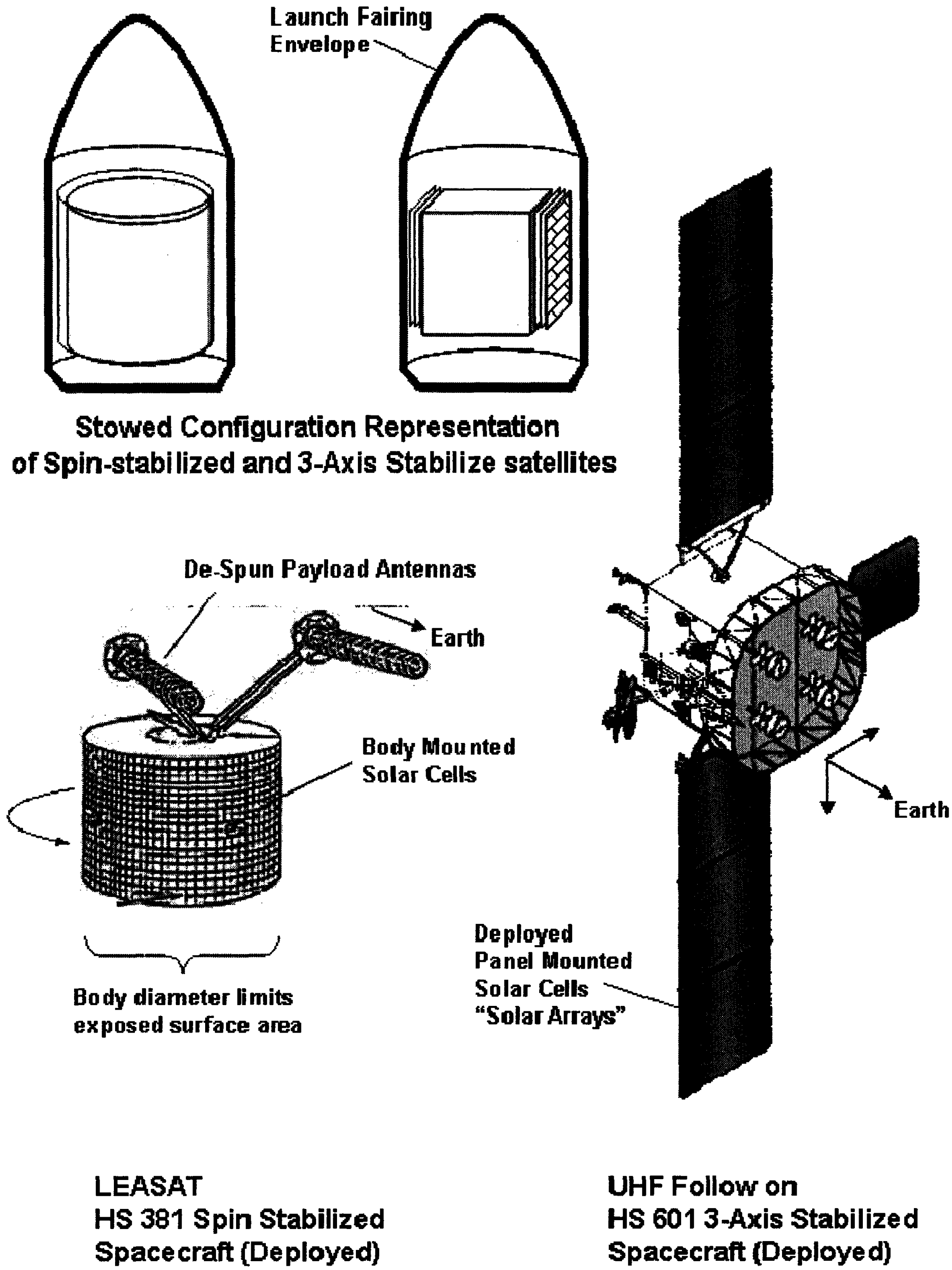


Figure 4.5 Hughes radical architecture change from LEASAT and UHF Follow-on

Hughes was the incumbent for the USN UHF LEASAT Program. LEASAT was developed to augment the Navy's Fleet Satellite (FLTSAT) Communications System. The name is derived from the business arrangement of the government leasing services from Hughes versus a direct acquisition of the satellites. LEASAT was launched by the Space Shuttle using the Hughes HS-381 "wide body" satellite.

Customer Follow On Objectives

The customer's objectives were first, transition from leasing to buying the satellites and second, to increase communication capacity.

An Incumbent Success

Hughes represents a rare example of an incumbent winning the follow on full and open competition. Coincidentally, Hughes was undergoing an internal architecture shift in technology. Their technology architecture transitioned from simpler spinning satellite to 3-axis stabilized satellite to enable higher power though larger solar array exposure. The coincidental timing along with a follow-on competition allowed Hughes to provide architecture innovation with no previous architecture constraint.

5.0 Interviews

Interviews with senior government and industry leadership directly responsible for follow on satellite competitions provided further in-depth insight to satellite competitions. Appendix A provides a sample questionnaire, interview approach and demographics of interviewees. Interviews and quotes used in this thesis are not attributed to specific individuals in the interests of confidentiality. They are all independent of the case studies described above.

General Observations

A number of quite distinct differences between incumbents and non-incumbents emerged from the interviews. These differences can be classified into three distinctive dimensions – cost, innovation i.e. performance improvement and management summarized in table 5.1. Along these dimensions incumbent vs. non-incumbent differences seem to show a striking similarity to those differences described by scholars working in a wide variety of sectors comparing incumbent and non-incumbent behavior.

Incumbent	Non-Incumbent(s)
COST	
• Actuals from incumbent program	• Parametric from adjacent successes
• Leverage heritage investment	• Leverage Adjacent Investments
• What Has Been	• What is Possible
• Bottoms Up	• Tops Down
• Pessimistic	• Optimistic
INNOVATION (PERFORMANCE)	
• Evolutionary (<2x)	• Revolutionary (>5x)
• Production Focus	• Development Focus
• Component Focus	• Architecture Focus
• Protect Core Competencies	• Open Trade Space
• State-of-Practice	• State-of-Art
MANAGEMENT	
• Existing Organization	• New Organization
• Resource Starved	• Resource Rich (2x)
• Existing Team & Responsibilities	• Best Team in Company/Industry
• "B" Team	• "A" team
• "Its ours to lose"	• "We have nothing to lose"
• Arrogant	• Confident
• Threat	• Opportunity
• Kill Competition	• Shape RFP (i.e. Attackers)
• Status Quo	• Relationship building/Mission partner
• Follower - Changes after last recourse	• 1st Mover and willing to take risks
• Risk Avoidance	• Risk Reduction
• Recoil From Negative Feedback	• Build on Negative Feedback

Table 5.1 General characteristics observed from interviews

Cost

> *"I wasn't scared, but I was up there looking around, and suddenly I realized I was sitting on top of a rocket built by the lowest bidder"*
>
> \- Alan Sheppard, (quoted by John Glenn)

Low cost bidding pressure to win has led some to argue an element of lying plays a role in the estimation process (Flyvbjerg, Holm, and Buhl 2002) (see Apendix B). A senior executive lamented:

> *"Its "Liars poker." Who can tell a better story."*

Another industry executive and former military officer echoed:

> *"Men cheat…It's the same thing"*

Nobel Laureate Daniel Kahneman, notable for his ground-breaking work on behavioral finance, established a cognitive basis for common human behavior. In ***Why Hawks Win (2007)***, Kaneman highlights this bias *"Excessive optimism is one of the most significant biases that psychologists have identified."* Interview remarks with regard to cost were highly consistent with the generally accepted theory that non-incumbents are more optimistic and "unburdened" in their cost offer.

A leading industry consultant provided a contrast of how the non-incumbent versus the incumbent approaches their cost:

> *"Non-Incumbents are ignorant of costs. They are bridging costs from existing program. These a more tops down, which tends to be optimistic vs. the incumbent which is estimating bottoms up from actual which tend to be more conservative"*

A senior industry executive further described how the non-incumbent has more flexibility in building their cost:

> *A non-incumbent can pick relevant programs to build cost basis of estimate – easier not to select trouble areas*

A former senior military officer in acquisition reinforced the "burdened" incumbent assertion:

> *The incumbent has ground truth. They (incumbents) are handicapped by their actual costs to execute the previous program.*

The Government has possibly reinforced low cost bidding despite best value criteria. A senior acquisition officer reflected:

> *"In recent years, there has been an increased emphasis on cost."*

Customers may also have a bias against incumbents providing a lower cost. One Industry executive commented on customer perspective when incumbents provide lower cost in their follow-on proposal:

> *"Why didn't you (incumbent) bring me this earlier? Do I have to have a competition in order to get better costs out of you?"*

Increasing past performance relevance as a means to improve incumbent consideration has been advocated (Young 2003). The FAR allowing non-incumbents with no relevant past performance experience to receive a "neutral" rating compounds the challenge of non-incumbents. This means the offeror is neither rewarded nor punished in the rating, and the source selection official must consider the neutral rating as neither a positive or negative. (Steyaert 1997). If large development programs typically overrun (see Appendix B), customers may also have a bias against incumbents past performance by a senior industry executive:

> *"Customer is mostly upset at the incumbent's overruns and schedule delays. The want a change in performance – The Government wants to open the competition"*

Although limited data exists on incumbent performing follow-on contracts after winning a full and open competition, it is not clear the incumbent is in any better position to execute a follow radical architecture change then a non-incumbent. One senior acquisition official replied to the question of if the incumbent was in any better position with an emphatic:

> *"No. They are not"*

Hughes UFO program provides a rare example of incumbent winning and executing. An added distinction was the UFO program was a Firm Fixed Price (FFP) contract. FFP contracts put the majority of cost and schedule risk on the contractor. However, given the inherent financial risk in large development programs, FFP contracts are an exception rather than the rule.

Innovation

As confirmed in the thesis interviews, low cost is a key selection criterion in satellite competitions. However, non-incumbents also win based on having the highest performance. Higher performance typically involves a radical innovation improvement (O'Connor et. al 2006) such as >5X in a key performance parameter or 30 to 50% cost reduction in a key area such as system operations or logistics. Two key reasons for a new competition are first, completion of all options on the incumbent contract, and second, requirements outgrow the incumbent system capability and its ability to evolve.

The second rationale was the dominant perspective provided including overriding the first reason. As one senior military officer explained:

> *"Unless there is a 10X improvement or a whole new capability then its better to sell up our chain of command an evolutionary change (sole source). We would look for every reason to extend the incumbent as long as they are performing and continue to evolve."*

A senior government acquisition official cited:

> *"Competition is needed when new user requirements outstrip the capability of the old technology"*

During a competition, the government keeps all competitive information proprietary. However, since the incumbent's program performance and cost are public domain, the non-incumbent starts from an extensive competitive intelligence advantage. This appears to be a driving factor in what motivates a non-incumbent to seek radical innovation.

A former senior military officer explained:

> *"They (non-incumbent) know what the incumbent can do so "I have to offer something much better" lean further ahead, more aggressive, forward leaning. They bring entrepreneurship, risk taking. They have nothing to lose!"*

Another former senior military executive also remarked:

> *"They can be a Monday morning quarterback – they can watch the incumbent and forecast what the incumbent is going to bid."*

A government acquisition official noted about incumbent behavior and innovation:

> *"The incumbent relies on past strengths and what was successful for them in the past. "Evolutionary"... baby steps. They don't think out of the box. Incumbent can't see something new or are afraid to do something radical"*

Another senior acquisition official reflected on briefing the follow-on program to senior government leadership:

> *"In Washington DC, everyone thought (contractor X) was the incumbent especially since they had been performing well and we were happy with them. We spent allot of time dispelling that within the Government because the follow on program requirements were so different and the architecture required such a revolutionary change. We never thought we had an incumbent for the new system."*

This comment dispels some notions that an incumbent contractor is always performing poorly for a re-competition to occur and an incumbent inertia favoring their heritage is more dominant. Two different senior acquisition officials recalled incumbents losing proposal for the follow on:

> *"(The Follow on) was not like (the Legacy program). It was not the same type of system. (Incumbent) didn't get out of the mindset it wasn't another (legacy satellite) which they had invested. When you are incumbent, you can't think out of the box. Maybe you can only make an incremental step"*

> *"The incumbent did not focus on performance. They tried just to improve on their existing system."*

Management

Management is the third prominent characteristic that emerges from the interviews as differentiating incumbents and non-incumbents. Management is highly correlated as the enabler for innovation or lack of innovation by their choices on how they respond to follow on competitions.

Incumbent senior management often holds project managers accountable for competitions. As one industry leader reflected:

> *"How did you screw up and let this (competition) happen? Instead of respecting competition is the normal course of business."*

Although incumbents focus on customers and execution, the relationship and attitudes change over time. A senior industry executive and former military officer explained:

> *"Incumbents become complacent, arrogant. Stuck to solution/attitude. "It's ours to lose" Incumbents try to kill the competition and try to drive sole-source. There focus is on execution and cost control on current contract and no focus on follow on"*

Another senior government acquisition official recalled:

> *"Incumbents think their doing great so they don't put their "A" team on the proposal. I've seen that 3 or 4 times"*

Management's response to risk is also characteristic of incumbents and non-incumbents. A senior industry consultant contrasted how incumbents and non-incumbents approach risk:

> *"The incumbent knows the answer and doesn't revisit trades or risk in how they arrived at the solution. The new entrant is willing to open up trades which then contributes to supporting their solution"*

Another senior industry executive provided an additional contrast between how incumbents and non-incumbents react to customer feedback when they each broach innovative ideas:

> *"When the incumbent tries a new idea and the customer reacts negatively the incumbent re-coil and does not try to push the risk boundaries again. When a non-incumbent receives a negative reaction from the customer, they listen, go back, think about it, and try something different factoring in the feedback. They build on the feedback"*

Skill mix also changes over the life of the incumbent program. As a senior industry, consultant and former senior military officer commented:

> *"Core team that won the original contract disperses over time. Incumbent is going to try to build on capital investment "Evolutionary vs. revolutionary" approach. They just don't view it the same way"*

Another senior industry leader and former senior military officer in acquisition added an additional perspective on the critical program knowledge:

> *"The longer the program runs expertise gets concentrated in the heads of a few. The key people know the formula. The incumbent rests on the laurels. People on a program keep information close because that's a source of power and their position on that program – no incentives to share information Good people tend to leave as there is no room to move up"*

Industrial base may also impede incumbent management by a perception they will be chosen to protect industrial base. The policy of the U.S. Government to provide for a strong industrial base (United States 2006) likely reinforces this belief. However, regardless of policy unanimous comment from interviewees was for government satellite competitions industrial base had no bearing on final selection.

A senior industry leader mentioned:

> *"From an evaluation standpoint, the customer does not think, "I need to spread work around"*

A former acquisition official commented:

> *"Studies are done at high level, but zero (influence) at my level. It never part of the decision. My job is to get the best capability to the user. When you get down to one or two shipyards, then maybe it comes up but not in space"*

A senior military acquisition official provides a perspective:

> *"With respect to industrial base, I don't look to make a decision on spread the work around. I will assess if the contractor has the abilities to perform the work."*

This viewpoint articulates how industrial base is confused with acquisition selection. In the end, a contractor's ability to execute is the driving factor. This may correlate in that if one contractor has too much work, they are less likely to have an ability to execute a new program. The advantage may shift to the other bidding contractor independent of incumbency.

6. Conclusion and Recommendation

"Making predictions is always difficult, particularly when they're about the future"
- Yogi Berra

Low cost, optimistic bidding by non-incumbents is a significant factor in source selection. However, architectural innovation and empowering management also seem to have an important underlying influence in the success of non-incumbents. A clear pattern of interaction between competition dynamics, dominant designs and architectural innovation supported by managerial flexibility emerged from the interviews. Figure 6.1 provides a more complete innovation view of the phenomena. As the incumbent completes CDR, a dominant design is established (Utterback 1994). This demarcates where product innovation diminishes and process innovation becomes prominent. A shift from heavyweight teams to functional teams also characterizes this phase (Christensen 2006). Incremental component innovation replaces radical architecture innovation. As user requirements continue to grow and the incumbent systems provide only incremental performance improvement, a disparity emerges. The customer inevitably explores radical innovation options both internally and externally. Incumbents with functional organization rigidities seek to protect core competencies (Leonard-Barton 1992), investments, and resist radical architecture changes. Non-incumbents unencumbered by an established architecture, provide radical alternative solutions (Henderson 1990) and maintain a "first mover advantage" (Lieberman 1988).

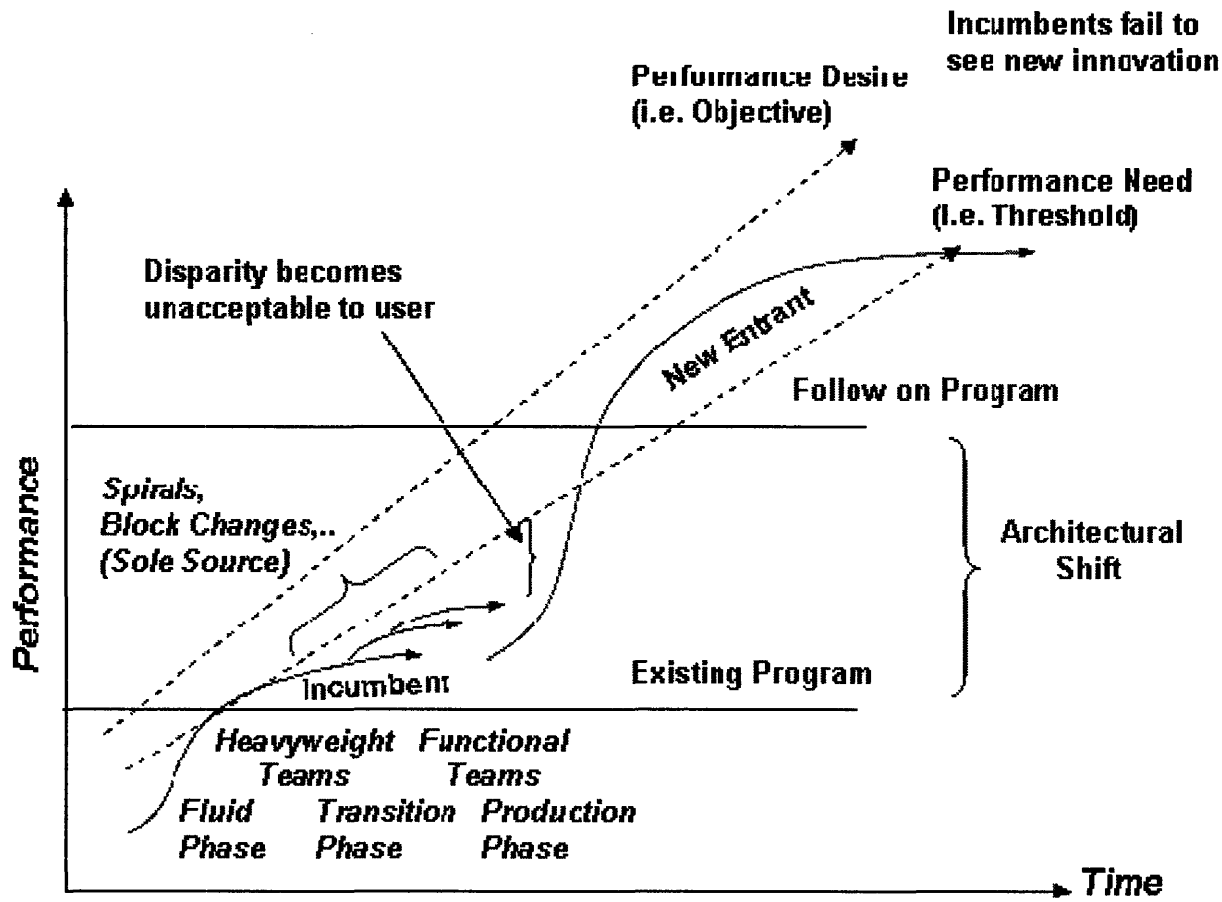


Figure 6-1 A holistic innovation view of satellite follow on competitions

The U.S. Government's desire to improve cost and schedule control over major satellite programs is driving attempts to shift acquisition policy and practices to increase scrutiny of non-incumbents proposals with an implicit goal of increasing incumbent follow-on contract awards in full and open competitions. Incumbent contractors are encouraged by these recommendations. However, sole-source contracting for follow-on systems is unlikely to succeed due to pressures by congressional oversight, non-incumbents and increasing separation of user needs and incumbent system capabilities. The second and most likely avenue via full and open competitions is the shifting emphasis on best value criteria (i.e. increasing non-cost criteria weighting). However, this thesis concludes that lowering cost evaluation criteria and increasing past performance criteria will unlikely change the underling phenomena of non-incumbents winning with higher performing architectures.

This finding poses two dilemmas; first, how does an incumbent win a follow on competitions; second, regardless of who wins, how does the government mitigate the inevitable cost and schedule difficulties of major new project developments.

To overcome the first dilemma, this thesis concludes a new architecture is required. Incumbents should actively pursue alternative architectures that achieve radical improvements beyond any potential incremental improvements with the existing architecture. Radical innovation requires heavyweight teams versus lightweight and functional teams executing the existing architecture. Autonomous organizations are required for disruptive innovation.

For the second dilemma of successfully executing a program, architecture innovation requires differences in technology and organizational management emphasis. First, for technology management, Technology Readiness Levels (TRLs) (see Appendix F) developed by NASA and applied to all space programs including the DoD, have done a great deal to track, manage and retire component development risk. However, TRLs provide no oversight to architecture development and risk retirement. A concept of a System Readiness Level (SRL) that will incorporate the current TRL scale, and introduce the concept of an integration readiness level (IRL) has been proposed at the Conference on Systems Engineering Research to mitigate the technical challenges of complex system developments (Sauser et. al, 2006). Further study in the methodology is required, but it is a start at addressing the underlying phenomenon of architecture change.

Finally, for organization management, new architectures require new organizational culture for the particular project. The embedding of organizational culture involves a teaching process, which may not be explicit (Schein, 1983). Consensuses on goals, norms, common language, power, rewards, punishments, etc. all have to be established. Focus on technical component maturity will continue to overlook new interface challenges in architectural and organizational development.

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Appendices

The following appendices provide further depth of information referenced in the main body of the thesis.

APPENDIX A - Interview Approach, Sample Questionnaire and demographics of Interviewees

Interview Candidates:
All interviewees have considerable experience in U.S. Government satellite acquisitions. Satellite contractors, consultants and government personnel were utilized for interviews.

Interview Objectives:
The primary objectives are to understand how incumbents, new entrants, and customers behave as a follow on competition occurs. This includes events leading up to initial considerations of having a competition through final award.

Interview Approach:
An email initiates a request for an interview along with a copy of the thesis abstract and a brief description.

Interviews lasted approximately an hour as requested.

Questions are used as a common guide. Not all questions were always asked due to time limitations. Instead, priority was given to gathering in-depth perspective to the particular interviewee and their expertise. The questionnaire was not provided in advance or during the interview.

Non-attribution:
Quotes are not attributed to any specific individual, program, or agency. Quotes attributed to any individual are at their prior-approval..

Sample Interview Questions:
Name: ________________ Title: __________________

Date of Interview: __________ Interview Method (i.e. Phone vs. face to face)

Company/Organization: ____________________________

Title/Role: ___________________________________

Years of experience: ______________ Years in present assignment: __________

Interview Objectives:

The primary objectives are to understand how incumbents, new entrants, and customers behave as a follow on competition occurs. This includes events leading up to initial considerations of having a competition through final award.

CUSTOMER

1. What are the options the customer is considering? (i.e. sole source, open competition)

NEW ENTRANT

2. What advantages does an incumbent have for a new competition? What Disadvantages?
3. How does a new entrant gain credibility with an established customer?
4. How does a new entrant show cost credibility with an established customer?

INCUMBENT CONTRACTOR

5. What advantages does an incumbent have for a new competition? What Disadvantages?

OTHER AWARD FACTORS

6. How much does political influence (national, state, or local) influence an acquisition?
7. Does industrial base influence an award decision? (if so how?)

BEST VALUE EVALUATION

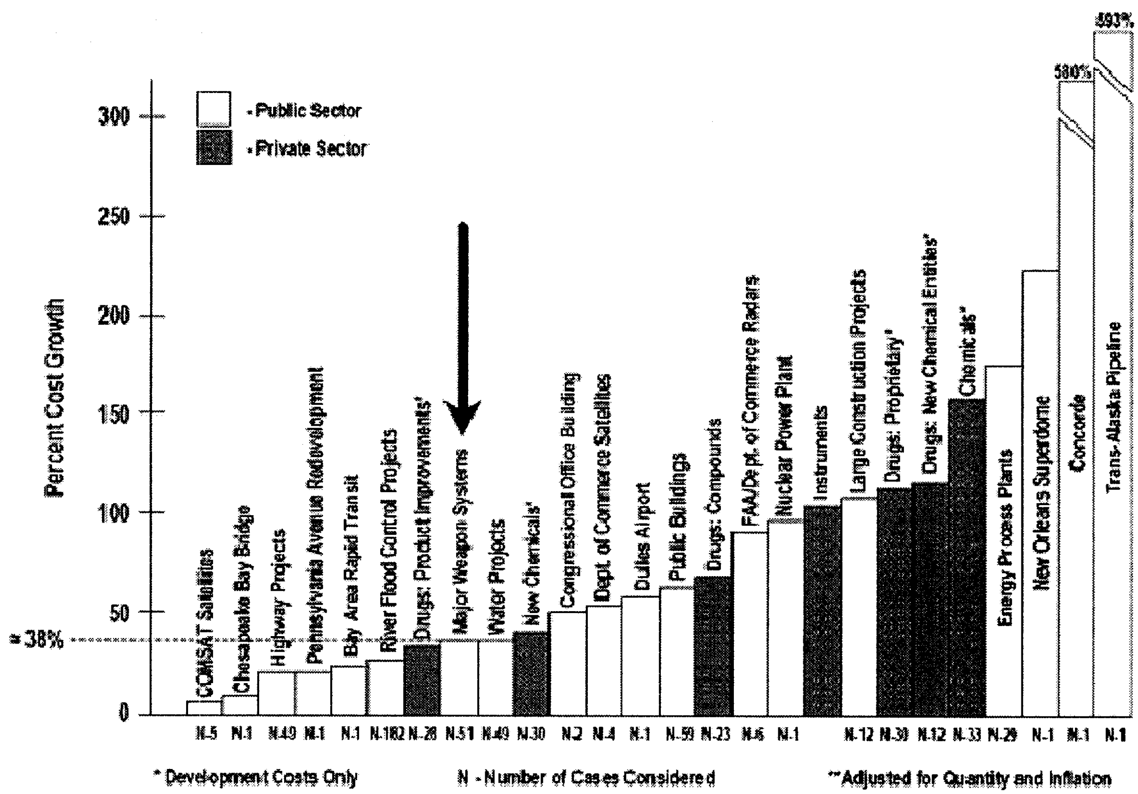
8. Best Value Award allows an award to a higher price, however the majority of awards to new entrants were lowest price as well – What factors do you feel contribute to this?
9. "Do you have any questions or feel there should be other inputs?"

ADDITIONAL DISCUSSION NOTES:

Interviews with government and industry leadership directly responsible for follow on satellite competitions provided in-depth insight to satellite competitions. A preliminary list of potential interviewees was drawn-up including both government interviewees with experience in sole source follow on awards to incumbents as well as full and open competitions and industry interviewees had experience non-incumbents winning follow on awards as well as losing to other non-incumbent winners, and non-incumbents winning sole source contracts, losing and winning full and open competitions. The objective of the interviews was to understand how incumbents, new entrants, and customers behave as a follow on competition occurs. This includes events leading up to initial considerations of either sole source or full and open competition through final award. Of the 19 interviews requested, 18 were conducted. 4 of the interviewees are currently in government acquisition positions and 14 are from industry representing 7 different aerospace companies. Of the 14 from industry, 8 had previously worked as government acquisition officials, mostly as military officers. An email initiated a request for an interview along with a copy of the thesis abstract. Most interviewees stayed within an hour as requested. Two interviews were conducted face-to-face. The remaining interviews were conducted one-on-one over the telephone with no discernable difference in quality of response. One industry interview over the phone was conducted with two individuals for their convenience. Case studies in chapter 6 are unrelated to data gathered in interviews. Case studies are completely developed though observation of competitions with public domain information.

Appendix B Historical Cost Growth of Large Development Projects

The purpose of this appendix is to look beyond satellite projects to other large project developments. Two reasons is to compare other projects relative to satellite and defense projects, and second to see if there are similar reasons for project overruns that can applied to the phenomena of satellite incumbents losing 9 out of 10 times. The Defense Acquisition Report cites a study by TASC[12] DOT&E collected data shown in Figure B-1 highlighting a system challenge across a myriad of large development projects in different industries.



Source: F. Biery, TASC, Inc., "Cost Growth and the Use of Competitive Acquisition Strategies." The National Estimator (Journal of *The National Estimating Society*), Vol. 6, No. 3 (Fall 1985).

Figure B-1 Development costs of major projects

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[12] Acquisition Trend Metrics In The Department Of Defense

Flyvbjerg, Holm, and Buhl[13] studied over 258 public works infrastructure projects worth $90B from different geographic regions, project types, and historical periods and found:

- 9 out of 10 transportation infrastructure projects, costs are underestimated.
- Cost underestimation has not decreased over the past 70 years. No learning that would improve cost estimate accuracy seems to take place.
- Cost underestimation cannot be explained by error and seems to be best explained by strategic misrepresentation, i.e., lying.
- Transportation infrastructure projects do not appear to be more prone to cost underestimation than are other types of large projects.

They explain cost underestimation can be characterized as four types: technical, economic, psychological, and political. Technical may be due to inadequate data, honest mistakes, or inherent problems in predicting the future problems. For economic explanations, two types of exist; one explains in terms of economic self-interest, the other in terms of the public interest. Psychological explanations are summarized as "appraisal optimism." Finally, political explanations construe cost underestimation in terms of interests and power both for the firm and public benefit. Flyvbjerg et. al. take a strong position with costs being strategically misrepresented, i.e. lying. This claim is hard to validate, however, appraisal optimism is consistent with cognitive bias (Kahneman 2007) and general human nature for optimistic outcome.

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[13] Underestimating Costs in Public Works Projects Error or Lie?, Bent Flyvbjerg, Mette Skamris Holm, and Søren Buhl APA Journal Summer 2002 Vol. 68, No. 3. 17 pp

APPENDIX C: Space Industrial Base Policy and Source Selection

A robust U.S. space industrial base is a prominent presidential, congressional and DoD policy. For the first time, the U.S. National Space Policy issued by President George W. Bush identifies the importance of a space industrial base

> *A robust science, technology, and industrial base is critical for U.S. space capabilities. Departments and agencies shall: encourage new discoveries in space science ...; and ensure the availability of space related industrial capabilities in support of critical government functions.*[14]

U.S. law also requires an annual report to congress;

(2) *A description of the methods and analyses being undertaken by the Department of Defense alone or in cooperation with other Federal agencies, to identify and address concerns regarding technological and industrial capabilities of the national technology and industrial base.*[15]

Additionally the 2006 U.S. 2006 Quadrennial Defense Review (QDR) mentions;

Improve responsive space access, satellite operations, and other space enabling capabilities such as the space industrial base, space science and technology efforts, and the space professional cadre.[16]

Industrial Base in a Competitive Source Selection

Industrial base is certainly a policy objective, however, for purposes of this thesis is, the question is; "does maintaining industrial base factor in source selection?" Interviewees were unanimous that they were unaware that any source selection where industrial base was a factor in source selection or even used as a factor. One senior government acquisition official commented,

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[14] U.S. National Space Policy Office of Science and Technology Policy, Executive Office of the President, The White House 31 Aug. 2006, released 06 Oct 2006
[15] U.S. Code TITLE 10 > Subtitle A > PART IV > CHAPTER 148 > SUBCHAPTER II > § 2504. Annual report to Congress
[16] 2006 Quadrennial Defense Review (QDR) Report, 57-58

"Industrial base studies are at a high level. "zero at my level It's Never part of the (acquisition) decision. My job is to get the best capability for the government. When you get down to one or two shipyards, then maybe it comes up but not in space"

Reviewing the FAR, which governs all DoD and NASA acquisitions, a search identifies Industrial Base in only two locations:

> 15.404-4 Profit.
> (a) *General.* This subsection prescribes policies for establishing the profit or fee portion of the Government prenegotiation objective in price negotiations based on cost analysis.
> ....
> (2) It is in the Government's interest to offer contractors opportunities for financial rewards sufficient to stimulate efficient contract performance, attract the best capabilities of qualified large and small business concerns to Government contracts, and **maintain a viable industrial base.**
>
> 17.106-3 Special procedures applicable to DoD, NASA, and the Coast Guard.
> (a) Participation by subcontractors, suppliers, and vendors. **In order to broaden the defense industrial base**, to the maximum extent practicable—
> (1) Multi-year contracting shall be used in such a manner as to seek, retain, and promote the use under such contracts of companies that are subcontractors, suppliers, and vendors; and
> (2) Upon accrual of any payment or other benefit under such a multi-year contract to any subcontractor, supplier, or vendor company participating in such contract, such payment or benefit shall be delivered to such company in the most expeditious manner practicable.

While the FAR is supportive of overall government policy, it does not provide explicit rules, guidance or advocacy for enabling acquisitions based on industrial base.

Appendix D – Evolutionary Acquisition (EA) and Spiral Development

In order to provide operational capabilities to users more quickly then recent trends, the DoD has mandated Evolutionary Acquisition (EA) as the preferred approach for acquiring systems.

EA avoids follow on competitions with sole source awards and providing low risk incremental or evolutionary improvements to the users. However, incumbents rarely, if never, bring radical innovation and ultimately are overtaken by non-incumbents satisfying users needs with newer technology and innovations.

The concept of EA is not new although more formally mandated. As an example, the B52 strategic bomber has been operational since 1954 and is on generation "G". Some experts expect it to be flying until at least 2040, with the potential of operational for 100 years.

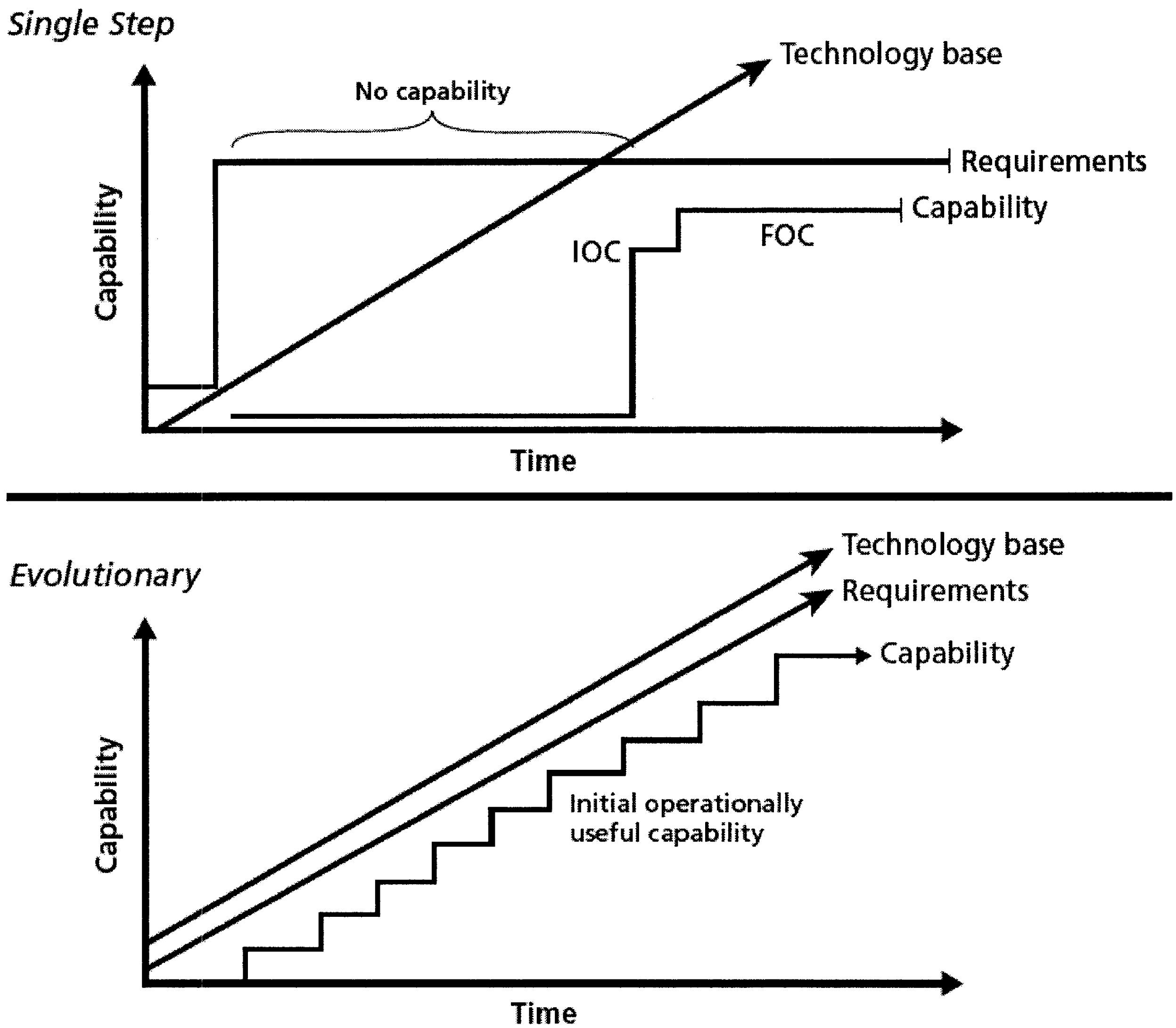
Per DoD policy, "Evolutionary acquisition strategies are the preferred approach to satisfying operational needs. Spiral development is the preferred process for executing such strategies." *(From DoD 5000.1, 12 May 03, paragraph 2.3.2)...*

The principal goal of EA strategies is to provide operationally useful capabilities to the Warfighter much more quickly than traditional acquisition strategies. Instead of the old approach of "single step to full capability," evolutionary acquisition aims at achieving an overall objective end capability through the more rapid fielding of numerous operationally useful threshold capabilities by pursuing less *demanding intermediary increments or steps.* (Lorell 2006)

The new National Security Space Acquisition Policy (NSSAP) 03-01 guidance mandates evolutionary acquisition as the preferred acquisition approach for space programs.

A graphical representation of single step vs. evolutionary acquisition is in Figure D-1. There are two development process options to implement the Evolutionary Acquisition Strategy. The first is Incremental Development in which the end-state performance requirement is known, and requirement will be met over time in several increments. The second option (and preferred option by the DoD) is Spiral Development in which the desired capability is identified, but end-state performance requirements are not known at the beginning of the program. Requirements for future increments are dependent upon technology maturation and user feedback from initial increments.

Although EA provides a reduced risk process to incrementally improved a platform or architecture, is may also reinforce core rigidities and organizational inertia for radical architecture innovations.



SOURCE: Lumb (2004, p. 12).
NOTES: IOC = initial operational capability; FOC = full operational capability.
RAND *MG431-1.1*

Figure D-1 Single Step versus Evolutionary Acquisition

Appendix E: Technology Readiness Level (TRL)

National Aeronautics and Space Administration (NASA) developed Technology Readiness Levels (TRLs) [17] to define level of maturity and associated risk of a particular space technology. NASA officially incorporated in the Management Instruction (NMI 7100)[18] which addresses integrated technology planning. The DoD officially adopted the standard[19] in 2004 in DODI 5000.2 Acquisition System Guidebook

By focusing on component technology, non-incumbents avoid demonstrating architecture maturity. TRL provides a tool to remove ambiguity component maturity. TRLs act as an unbiased benchmarking for contractors to show technical maturity and associated risk with their solution. i.e. "As a new entrant I'm using your (government) criteria so you can not lower my evaluation score". Its equally valuable to incumbents, but if incumbents are leveraging off of older proven (and lower performance) then they are not stretching as far. The DoD (and GAO?) had tried to set minimum goals (i.e. all TRLs >5) for award but they backed off on a hard cut off and TRLs < 6 would be evaluated as higher risk but not rejected.

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[17] John C. Mankins, TECHNOLOGY READINESS LEVELS , April 6, 1995 Advanced Concepts Office, Office of Space Access and Technology NASA

[18] NASA Management Instruction (NMI 7100)

[19] Technology Readiness Levels in the Department of Defense (DOD), DOD (2004), DODI 5000.2 Acquisition System Guidebook)

Table E-1. TRL Scale for Assessing Critical Technologies

Technology Readiness Levels	**Technology Readiness Level Description**
1. Basic principles observed and reported.	Lowest level of technology readiness. Scientific research begins to be translated into technology's basic properties.
2. Technology concept and/or application formulated.	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.
3. Analytical and experimental critical function and/or characteristic proof of concept.	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4. Component and/or breadboard validation in laboratory environment.	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in a laboratory.
5. Component and/or breadboard validation in relevant environment.	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in simulated environment. Examples include "high fidelity" laboratory integration of components.
6. System/subsystem model or prototype demonstration in a relevant environment.	Representative model or prototype system, which is well beyond the breadboard tested for level 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment.
7. System prototype demonstration in an operational environment.	Prototype near or at planned operational system. Represents a major step up from level 6, requiring the demonstration of an actual system prototype in an operational environment. Examples include testing the prototype in a test bed aircraft.
8. Actual system completed and qualified through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this level represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9. Actual system proven through successful mission operations.	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions.

Appendix F - Observations in other Government Acquisitions

Classified Space Programs

For security purposes, National Security Classified programs were not explicitly identified or reviewed. Where public domain data is available from U.S. government sources, and is relevant for discussion then appropriate inclusion is made.

Although specific discussions of programs are beyond the scope of this study, a different paradigm has been observed as noted by Robert L. Butterworth (2000).

> *"Nor was there much opportunity in the classified space world to introduce competition in production. Total lifetime quantities for even longstanding programs might amount to fewer than 20 units (often far fewer). In principle, bloc changes provided an opportunity to recompete a program and bring in new approaches. In practice, only once in the first 30 years did a competing incumbent fail to win the follow-on contract."*[20]

Proper security access and control would be required for further study. However, possible hypothesis to explore may consider numbers of suppliers and accessibility to this market as potential differentiator. Also, per this thesis conclusion, the degree to which follow on systems provided by incumbents were evolutionary or radical architectural changes as well as the degree disparity between incumbent system capability and user requirements.

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[20] Growing the Space Industrial Base Policy Pitfalls and Prospects Robert L. Butterworth Visiting Professor of International Security Studies Air War College Maxwell Paper No. 23 Maxwell Air Force Base, Alabama September 2000 Air University

SM&A Observations

Steve Myers & Associates (SM&A) has observed similar phenomena in other DoD acquisitions. Established in 1982, SM&A is a professional proposal management service company specializing in Aerospace and defense competitions. SM&A achieved an 85% Win Rate on over a 1000 proposals worth more than $340 billion. Table F-1 provides a summary of various DoD competitions. Their observation shows similar trends and characteristic behavior of incumbents and new entrants such as challengers proposing "out of the box" solutions and recruiting the best team and personnel. SM&A concludes: *Incumbents play defense, challengers play offense.* Further study of their cases would be required; however, the trends and findings support the findings of this thesis.

Table F-1 Various DoD Competition Outcomes; Source: Steve Meyers & Associates (2006)

Project	Losing Incumbent's)	Winner
DoD Communications (DSCS III)	TRW	GE
Navigation (GPS) Phase 2	Rockwell	GE
Navigation (GPS) Phase 3	Lockheed Martin	Rockwell
Space Surveillance	Hughes & TRW	Lockheed Martin
NASA Communications (TDRS H,I,J)	TRW	Hughes
Navy Ship Defense (ESSM)	Raytheon	Hughes
Tomahawk Cruise Missile (TBIP)	MDC	Hughes
Shuttle Follow-On (X-33)	Rockwell & MDC	Lockheed Martin
Space Launch (MLV I)	General Dynamics	MDC
Shuttle Processing	Rockwell & Martin	Lockheed
Environmental Remediation (SAC TERC)	IT	ICF Kaiser
Space Weapons (KE ASAT)	Lockheed & MDC	Rockwell
Military Air Surveillance (R/SAOC)	Hughes	Litton
Future Information Architecture (FIA)	Lockheed Martin	Boeing

Navy Aircraft Carrier Attack Strike Fighters

U.S. Navy aircraft carrier top line fighter aircraft are amazing displays of engineering. The ability to be catapulted off a moving ship, accelerate to supersonic speeds, "dog fight" with enemy aircraft, and ultimately land (sometimes referred as a "controlled crash") on a rolling ship at night is remarkable.

A review of the Navy's strike fighter procurements and follow on replacements shows a pattern of incumbents losing follow on replacements to non-incumbents. There is also a pattern of considerable overlap of incumbent block upgrades after the follow on program awarded to a non-incumbent competitor. All theses fighter contracts have lucrative block changes extending the life of the fighter. Block changes are much lower risk, and take advantage of the existing capital and organizational structure. A possible conclusion consistent with this thesis is incumbent resources are committed to the older program architecture reinforced by high return on existing assets. Additionally, follow on fighters may not be perceived as a threat to the incumbent program as the two fighter co-exist for many years.

Table F-2 Summary of U.S. Navy Jet Top line Carrier Fighters

Fighter Designation	Prime Contractor	Losing Contractor (s)	Contract Award	First Operational	Final Block Upgrades/Operational	Decommissioned
F-4 Phantom	McDonnell Douglas		1955	1960	F-4G 1979	1987
F-14 Tomcat	Grumman	McDonnell Douglas, North American, LTV, General Dynamics	1969	1974	F-14D 2000	2006
F-18 Hornet	McDonnell Douglas	Northrop* (later teamed with MD)	1975	1983	F-18 C/D 1987; F-18 E/F 2002	2030 ECD
F-35C Lightning	Lockheed Martin Northup Grumman	Boeing (McDonnell Douglas)	2001	2011	TDB	2050 ECD

- Note: Northrop and MD had agreed on a partnership which later fell apart; F35 is also the follow on for the USAF F16 also built by Lockheed Martin (the incumbent).

Finally, these block changes tend to have incremental improvements at significant cost as cited by the GAO in the study of a F-18 block change:

> *"Given the high cost and marginal operational improvements that the F/A-18E/F would provide, this report recommends that the Secretary of Defense reconsider the decision to produce the F/A-18E/F aircraft and, instead, consider procuring additional F/A-18C/Ds until the next generation strike fighter achieves operational capability.....We believe that implementing our suggested approach could result in savings of almost $17 billion."*
>
> (GAO/NSIAD-96-98 Navy Aviation)

Implications

Although, these cases represent a small selective sample of overall DoD programs, the pattern observed by this thesis is prevalent in other systems. A more comprehensive study is required, but hopefully variables of architecture innovations, requirements disparity and incumbent inertia will factor into these studies beyond low cost biding analysis.

ACRONYMS

CER	Cost Estimating Relationships
CPAR	Contractor Performance Assessment Reporting System
CRS	Congressional Research Service
DoD	Department of Defense
DoE	Department of Energy
EOS	Earth Observation System
FAR	Federal Acquisition Regulations
FOIA	Freedom of Information Act
GAO	Government Accountability Office (Renamed from General Accounting Office)
GEO	Geosynchronous Earth Orbit
GSFC	Goddard Space Flight Center
GPS	Global Positioning System
HEO	Highly Elliptical Orbit
LEO	Low Earth Orbit
LV	Launch Vehicle
MEO	Medium Earth Orbit
MILSATCOM	Military Satellite Communications
MUOS	Mobile User objective System
NASA	National Aeronautics and Space Administration
NOAA	National Oceanographic and Atmospheric Administration
ORD	Operational Requirements Document
RFP	Request for Proposal
SATCOM	Satellite Communications
S/C	Spacecraft
TRL	Technology Readiness Level
UFO	UHF Follow on
UHF	Ultrahigh Frequency
UHF F/O	UHF Follow on
U.S.	United States
USAF	United States Air Force
USN	Unites States Navy
WGS	Wideband Global SATCOM (Formerly Wideband Gapfiller Satellite)