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Finding the Silver Lining:
A Guide to Positive Fiscal Analysis of a Prospective Venture
(or, A Primer for Pitching Your Pet Project to Corporate)

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Abstract

This paper explores financial modeling as an engineering tool which can quantify the positive attributes of a development project in a manner that fiscally-oriented executives and managers can readily absorb. After an orientation on the viewpoints and strategies of these corporate decision-makers, an introduction to common financial metrics, such as net income, rates of return, and break-even period, further prepares the reader to tackle the all-important topic of corporate goals and their contrast to government objectives. Basic concepts and methods for preparing projections of fiscal metrics for life-cycle project costs and benefits are explained, and examples are provided from the Engineering Cost Group's analysis of the Reusable Launch Vehicle Program at Marshall Space Flight Center. Brief discussions of techniques for analyzing and presenting results and conducting probabilistic models conclude the paper.

Introduction and Background

Engineers often develop more possessiveness about their tasks than other technical vocations, because design and development require a somewhat more personal investment. This might help to explain why engineers feel a more acute sense of loss when their project is terminated by factors beyond their control. What are these factors, and are they really wholly beyond the engineer's sphere of influence? Not entirely; at least, they don't have to be.

In today's relatively tight economic times, engineers encounter increasing resistance from their organization's decision-makers about undertaking new projects. Engineers often resent the "bean counters, " or financial planners, of the organization, whom they feel do not work hard enough to justify the economic existence of new technical projects. On the other hand, even if these financial planners are experts, they will still have difficulty picking out the profitable aspects of a project from a pile of specifications. Unfortunate as it may be, this trend in the U.S. will continue as more countries worldwide become competitive in implementing technical projects.

The United States, until recently, enjoyed world leadership in space technology. Over the last two decades, however, the U.S. share of the world launch vehicle market has dropped, due to competition from the French and their partners in the Arianne series, among others. In the Access to Space Study [NASA, 1993], a team representing a mix of U. S. aerospace industry and government agencies concluded that the U.S. should make a daring leap into development of new launch vehicle technology, with the goal of reducing launch costs by an order of magnitude. This ambitious strategy centered around setting the program's sights on advanced technology development for a technically-demanding single-stage-to-orbit (SSTO) vehicle, because of its potential y lower operating cost. This lower launch cost, if translated into lower launch prices, could open up new utilizations of space flight and re-assert U.S. leadership in space.

At the Marshall Space Flight Center (MSFC), near Huntsville, AL, hardware testing has begun for some of these SSTO-enabling technologies, such as composite structures and advanced propulsion. Other activities at MSFC have focused on the business structure of what has become known as RLV--the Reusable Launch Vehicle. The Engineering Cost Group, led by Mr. Joe Hamaker, was involved in initial financial analyses during the creation of the Access to Space Study, and, since then, this office has been the site of some interesting and unusual analysis. RLV is taking shape in the form of an innovative outsourcing approach to NASA's future launch needs, where with an industry partner or team develops and builds the launch vehicle under a cooperative agreement, with several possible modes of assistance, or incentives, from the U.S. Government (Table 1), which would then begin purchasing launches on the RLV around the turn of the century. Incentives for the industry to develop the RLV could come in many diverse forms, over a wide range of application times, but to be realized, they must be shown to be necessary for the survival of the program. Our job in Engineering Cost was to develop a model that could be quickly and easily modified to reflect the impacts of these various incentives on the program.

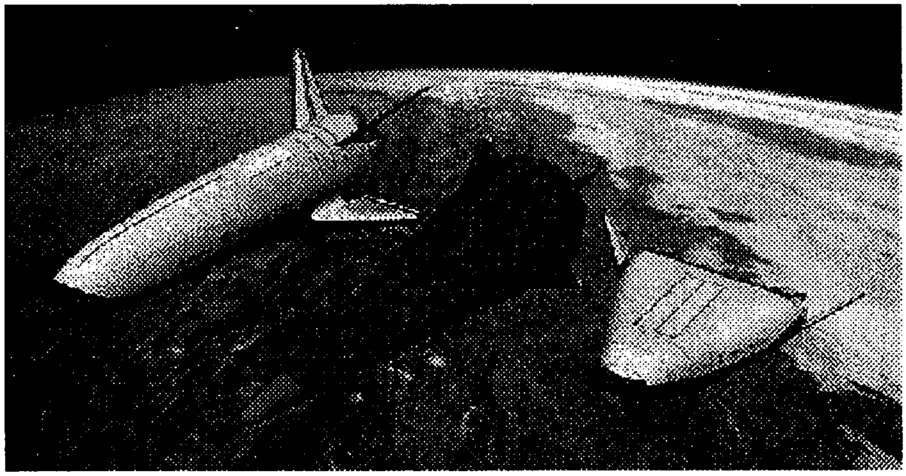

Figure 1: Industry Concepts for the RLV

Incentive	Description	Timing of Cost	Comments
Space Act Agreement Cost Offsets	Co-investment in development costs by NASA	Early (first 5 years of program)	Could lower cost by in-kind contributions
Government-Guaranteed Low-Interest Loan	Loan guaranteed for lender interest rate discount	Late to very late, depending on loan term	Could also raise debt % for higher ROE
Gov't-Subsidued Very-Low-Interest Loan	Loan subsidized by Gov't rate discount	Late to very late	Other agency might bear cost
Anchor Tenancy Premiums	Portion of STS vs. RLV cost savings returned	Medium (start of flight operations)	Additional outlay remains budget-neutral
Tax Holiday (First years of taxable income)	Relief from income tax liability	Medium to late (no effect until break-even)	Cost borne by Government budget overall
Tax Credit	Credit for a % of certain costs (e.g., DDT&E)	Medium to late (no effect until break-even)	Cost borne by Government budget overall

Table 1: **Characteristics of Possible Government Incentives for an RLV Industry Partner**

As part of Program Development at MSFC, the Engineering Cost Group had seen several promising young programs (Heavy Lift Launch Vehicle, National AeroSpace Plane, and National Launch System, to name just a few) fall by the wayside due to lack of justification or insufficient benefits with respect to cost. RLV, on the other hand, appeared to be a viable, potentially revolutionizing program for the U. S., NASA, and particularly for MSFC, the Propulsion Center of Excellence for NASA. While economic modeling must be objective and incorporate all significant known effects, the model builder usually exerts some influence on the outcome--not only of the modeling process, but also of the program itself--by the assumptions made in the model and by feedback of the results to program management. This feedback is especial] y beneficial to the model builder who advocates the project. Alerting project management to potential problems and highlighting variables that have more-than-average significance on the outcome of the project helps to mitigate problems and focus effort on optimizing the important aspects of the program.

Young projects that fail governmental analyses usually have insufficient benefits to justify the expense. In the RLV program, though, the focus of our modeling is not only on the government's benefit. The commercial prospects must be attractive enough to involve aerospace companies or teams large enough to commit the multi-billion-dollar investment, and the market potential must be large enough to ensure that the enterprise can stay solvent. To predict the reaction of the business world to the RLV, Engineering Cost had to step outside typical government cost analyses and construct a business model, complete with profit-based fiscal metrics, tax calculations, and equity considerations, to see if the program could be successful, and at what cost.

In industry, when a project is killed, the reasons given are usually something like "it doesn't show enough potential, " or, " it's too risky. " The engineer correctly interprets these as "the profit doesn't look good enough. " Several possible remedies for the widespread problem of underestimation of a project's worth can be suggested. First, the engineer could start his or her own company to realize the project. Unfortunately, the engineer-led company will still have the financial wickets to go through, only now at the bank or other capital source that may be even more demanding than internal sources. In addition, if the engineer assesses the worth of the product too optimistically y, the results can be financially disastrous. The engineer who possesses leadership and business skills, though, can make this approach successful.

Another possible remedy to avoid untimely project termination could be to bring the financial planners into the project much earlier in the product life cycle and let them work more closely with the design team. The Integrated Product Team (IPT) environment would be ideal for the inclusion of financial advisors, except for one problem: engineers and financial planners speak different languages. The educational and vocational processes that underlie each profession have imparted their own peculiar vocabularies and value systems to these professionals. Without the ability to communicate with the financial planners on the project team, the engineer again faces an uphill battle for project survival. In fact, any effort to raise engineers' batting averages on new projects must include familiarization with the financial planner's culture.

In order to be successful at pitching new projects, then, the engineer has to cultivate the ability to help the financial planners see the positive points in the project, in terms that they can understand and, if possible, convert to dollars. To accomplish this, engineers must understand the financial planners' goals and how the project relates to those goals, and they must communicate this to the financial planners in their native language. These skills go past Engineering Economy 101, but the rewards will certainly justify the effort. As a matter of fact, not only will learning some new fiscal yardsticks help your efforts to promote your project effectively, but learning how to maximize these financial metrics in your project may also help you uncover new ideas that improve your project and even your effectiveness on it.

Goals

Goals can be expressed in terms of utility, cost, prestige, fulfillment, safety, and many other units, but some are easier to define and measure than others. Personal goals are usually more difficult to quantify than business goals, but even these tacitly include the personal goals of the decision-maker, the financial planner, the engineer, and anyone else involved in the goal-setting process.

Measurability is one of the most important characteristics of well-set goals. In order to add value to the decision-making process, goals must define the criteria which can demonstrate positive progress to the decision-maker, or other intervening audiences. Goals also must be relevant to the organization's goals (as perceived by the decision maker or representative), and they must be free of ambiguity. Some goals lend themselves to quantification by one metric more than another, and the same goal may be measured with different metrics by different groups. One group might settle on the number of pounds of sugar consumed per capita as a valid metric for a society's affluence, while another group might choose average bank account balance. Furthermore, even the same metric may be interpreted inconsistently between different audiences.

For example, money provides low-common-denominator metrics, which means that many goals can be redefined in fiscal terms. On the other hand, its wide applicability also creates many difficulties. Money is generally worth more today than tomorrow, so fiscal metrics that span more than a few years must be modified to account for inflation and interest rates. A country's money will also change value with respect to worldwide markets. This type of unknown variable adds uncertainty to a goal, which should then be expressed as a range of possible acceptable outcomes. The decision-maker, the financial planner and the engineer, with their diverse backgrounds, all view money and its value through the filter of their own unique education and career experience. Similarly, with other metrics, these groups individualize the many goals of a project, applying the metrics that relate to their background and experience. By examining some of the possible project goals and some of their metrics, a greater understanding can be gained of how engineering goals and values can be translated into terms that help the decision-makers rule in favor of your project.

Setting Goals in Technical Environments

Engineering Issues: Decision-Maker = Lead Engineer, Division Vice President, President

- Does it work? (Satisfaction of Requirements)
- Does it work well? (Performance Optimization)
- Does it do lots of neat things? (Functional Optimization)
- Does it do what it's supposed to? (Requirement Validity)
- Is it pretty, or at least minimally offensive? (Aesthetics)
- Is it the best/biggest/fastest/smallest ever? (Peer Prestige)
- Can you fix it easily and cheaply when it breaks? (Maintainability)
- Is it bigger/better/faster/smaller than the other company's? (Competitive Spirit)
- Will Corporate buy into it? (Reality Check)
- Will it wimp out on you? (Reliability)
- Could it harm someone? (Safety)
- Is it easy to use? (Operability)
- Is it robust? (Durability)

Table 2: **The Goals of Development and Design Engineers**

These tables list some of the common questions that relate to goal-setting for technical projects by the different groups involved. The preceding Table 2 gives a sample of typical engineering approaches to common issues. Note the emphasis on performance-related criteria and pride of craftsmanship. This list may seem simplistic to an engineer, but a finance-oriented person will not usually have the necessary background and vocabulary to understand these terms, let alone convert them to economic equivalents.

Fiscal Issues: Decision-Maker = Boards of Directors/Stockholders, CEO, Intermediaries

- How much do we make on it? (Profitability)
- How much does it cost? (Baseline Cost Estimate)
- How soon do we start making it? (Rate of Return)
- How big is its market? (Financial Risk)
- When does it pay for itself? (Break-Even Period)
- Is it on budget? (Spending Profile)
- Can we reach and attract its market? (Marketability)
- Could it harm someone? (Liability)
- Will we get sued for making it? (Patent Infringement)
- What resources does it require? (Capital Requirements)
- Is it the best/biggest/fastest/smallest ever? (Market Prestige vs. Peer Prestige)
- Is it bigger/better/faster/smaller than the other company's? (Competitive Edge vs. Spirit)
- How sure are we that it will work? (Technical Risk, vs. Satisfaction of Requirements)
- Does it cost the same today as it did yesterday? (Cost Growth)
- Does it do what it's supposed to? (Requirement Validity)

Table 3: **The Goals of Financial Planners**

In contrast to the engineer, corporate financial planners do not create these technical projects, so their job-related gratification must come from other sources. Some engineers who have lost projects in the past might argue that wielding enough power to kill a project gratifies the financial planner, but the actual reason for the financial analyst's high standards may come from the fact that the financial aspects of any one project usually account for only a portion of any financial planner's job scope. She or he is not simply evaluated on the outcome of one project at a time, but on many. In fact, that person's job might be threatened if an undeserving project is supported, and then fails. So, in order to be as confident as possible of the project's viability, the analyst looks at the project with all of the available tools, objective indicators of the success of a project in concrete terms. These indicators can gauge many aspects of the project, as seen in Table 3, but they can also lead to confusion among those working on the project being evaluated.

Engineers with no financial analysis experience might find this list much harder to understand than the previous one. Some of the questions that these two different groups ask are the same, but their reasons for asking may differ. For example, both groups are interested in implementing the project safely, primarily, we assume, to prevent loss of life and limb. Past that implicit reason, their motives diverge: the financial planner is concerned with economic liability in, and probability of, worst-case scenarios, and how they might affect the company, while the engineer feels a greater personal responsibility for the safety of the user with respect to the product. Likewise, the concept of the biggest and best on the market appeals to the engineer's pride in his or her work, whereas the financial planner quantifies these characteristics, fiscally, in terms of market advantage or publicity value.

Economic Modeling Basics

Economic Analysis and the Mission

Behind the organization's goals for the project lie overall goals: a mission. Many organizations--from companies, retail outlets and offices to governmental agencies, non-profit organizations and military units--do not have mission statements, i.e., clearly-written descriptions of what the organization does, and why. As a matter of fact, quite a few of their members could not write one if told to, because they don't know *why* they do *what* they do. Obviously, the goal-setting process begins here, and so does the economic analysis. The analyst must have a clear picture of the organization's charter, and the relevance of the project to it, before beginning the model. At this fundamental level, different types of organizations have different missions, which has profound influence on what is considered a successful project. The two organizational cultures most relevant to the engineer are governmental and corporate cultures. The uniqueness of the RLV program lies in its cooperative nature between these two very different environments.

Corporate Culture

The corporation's primary mission is to make money for its stockholders or investors. This statement deceives in its simplicity, though. Would the stockholders prefer money now, or later? How long can the corporation afford to keep their money? Can it afford to implement a project this large? Does it want one that small? Several basic concepts arise in analysis in this environment, and understanding of these is crucial for conducting or interpreting economic analyses. (Revisit Table 3 for a very quick definition of other fiscal analysis terms.)

A company's **time horizon** is the amount of time in the future that analysis is deemed fiscally relevant. For example, a typical aerospace company would consider 5-10 years an acceptable horizon. A company might be persuaded to wait 15 years to break even, if the risk involved in the project was low. **Risk** comes in many forms, including financial, technical and safety, but all types of risk tend to shorten the acceptable horizon. The more risk, or uncertainty, involved in a project, the sooner the company wants money back from it. Risk also drives up the minimum **acceptable rate of return (MARR),** also called the **hurdle rate.** A **rate of return (ROR)** is an indicator of how much money an investor gets back and how soon. Getting more dividends and getting dividends sooner both increase the investor's ROR. A *company's* MARR, then, is how much money *it* can make, how soon, when it invests. This MARR also happens to be the "hurdle" the company needs to clear on any project that it undertakes. In our analysis, the baseline case sees the RLV project making around 18% annual ROR. Finally, the money that the company can afford to invest in the program is called **capital availability.** Since RLV is estimated to need between 4 and 8 billion dollars investment from industry, the maximum capital requirements play an important role in this economic model.

Government Culture

In contrast to the corporate mission, the U.S. Government mission concerns the "common good, " which is admittedly nebulous, but this concept can still indicate what metrics might be used by governmental agencies to judge projects. **Cost savings** for the taxpayer are good, and they can be combined with up-front costs to establish a rate of return. The government's "stockholders" will accept a lower ROR because of its great credit rating: a savings bond has a comparatively low ROR, but investors know they'll get their money back. The Government's horizon is very far, relative to industry, but, perversely, funding for the next fiscal cycle, the **budget,** is always a battle.

Modeling Guidelines

When building a model to measure the possible success of a project, all significant known costs throughout the life cycle of the product must be considered in the analysis. The time-value of money must also be taken into account. Use most-likely values for the baseline analysis, but don't be satisfied with one "answer." Run the model with ranges of likely values, and find out which variables affect the outcome the most. The analysis will require some assumptions; document sources in case you are asked where they came from.

Before the first formula is constructed in the spreadsheet, though, give some thought to how your model will be used, and how it should be arranged. In the RLV economic model (Figure 2), all input and output variables are brought up to one screen to enable quick feedback on changes in the inputs.

RLV Case Study Model			**NASA MSFC Engineering Cost Office / PP03 - PRELIMINARY**								15-Feb-96	
Input Parameters		* variable manually overridden			all figures in $B, rates are steady state (SS) / annual / marke							
Major Vars	Gross Nonrecur Costs			Sp Act	Net	Perc	Eff Ann	Tot Ann	Total S	# Yrs	% Delta	Tot SS
Excursion:	Facility	Fleet Pr	DDT&E	Offset	DDT&E	Debt	Mkt Rt	SS Rev	Fl Rate	Anchor	Anchor	Op Cst
With Veh Rel	0.500	2.000	[illegible]	0.000	6.000	40%	[illegible]	2.300	36	5.00	0%	0.680
Point of Depart.	0.500	2.000	6.000	0.000	6.000	40%	10%	2.300	36	5.00	0%	0.680
Feeder Vars	Fleet Produc		95 STS	STS %$	RLV Price/Flight by Class			SS Flight Rates by Class			SS Op Cost	
Excursion:	Unit $	# Veh	Cost/Flt	Impv/Yr	STS	Delta	Atlas	STS	Delta	Atlas	Fixed	Per Flt
With Veh Rel &	1.000	2.000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	[illegible]	[illegible]
Point of Depart.	1.000	2.000	0.400	0.027	0.100	0.025	0.050	16	12	8	0.500	0.005
Indus Invest	RLV	Veh Fl	Fleet Buildup		DDT&E Expend		Facility Expend		Tax Holiday		Debt Service	
Excursion:	Div?	Life	Start	End	Start	End	Start	End	Start	Span	Start	Term
With Veh Rel &	n	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2009	[illegible]	2003	10.0
Point of Depart.	n	440	2003	2006	2000	2005	2002	2004	2009	0	2004	10.0
Govt Invest	Dev Prog Exp*		STS UG		RLV Transition		Price Decrease		Final	Total $	SS Ops Phase	
Excursion:	Total	Start	Total	Start	Start	Span	Start	Span	Price	Incent	Start	Span
With Veh Rel &	0.825	1996.8	6.000	2001	2005	2	2011	2	0.100	0.000	[illegible]	[illegible]
Point of Depart.	0.825	1996.8	6.000	2001	2005	2	2011	2	0.100	0.000	2007	24
Results:	With Veh Rel & Prepay											
Major Vars	Ind IRR wrt Tax		Ind ATax NPV @		Govt IRR		w/UG << Govt NPV @ >> w/o UG				Total	Total $
Excursion:	Before	After	15.0%	20.0%	STS UG	No UG	15.0%	[illegible]	15.0%	20.0%	ROR	Anchor
With Veh Rel &	20.2%	16.1%	0.205	(0.369)	59.0%	30.5%	5.314	2.659	2.916	1.027	17.8%	0.000
Point of Depart.	20.2%	16.1%	0.205	(0.369)	59.0%	30.5%	5.314	2.659	2.916	1.027	17.8%	0.000

Figure 2: RLV Economic Model Input/Output Area

The point of departure variable values remain on separate lines, to enable easy comparison to the excursion being run. The years are arranged vertically, and each cost and revenue item for each year is detailed, which helps to cut down on complex formulae. The model is built in sections: Flight Rates, Government Cash Flow, and Industry Cash Flow, Income Statement, Balance Sheet, and Depreciation. The final consideration before beginning construction on the model is to decide what metrics your project will be measured by. Common metrics include ROR, ROE (return on equity, not including debt), break-even period, maximum capital requirements, and return on net assets (RONA), but the best metrics are always those that will reach your audience.

Showing the Project's Good Side

Now that the model is constructed, how does the analyst maximize the positive aspects of the project? Consider the type of organization and its associated characteristics, and concentrate on those parameters to which the most important parameters showed sensitivity. For example, Figure 3 shows the sensitivity of ROE to changes in debt level and interest rate on non-equity financing. The graph indicates that higher debt levels and lower interest rates raise return on equity. Since higher debt produced more positive effects than did lower interest rates, the project should concentrate on reducing risk, in order to attract more financing.

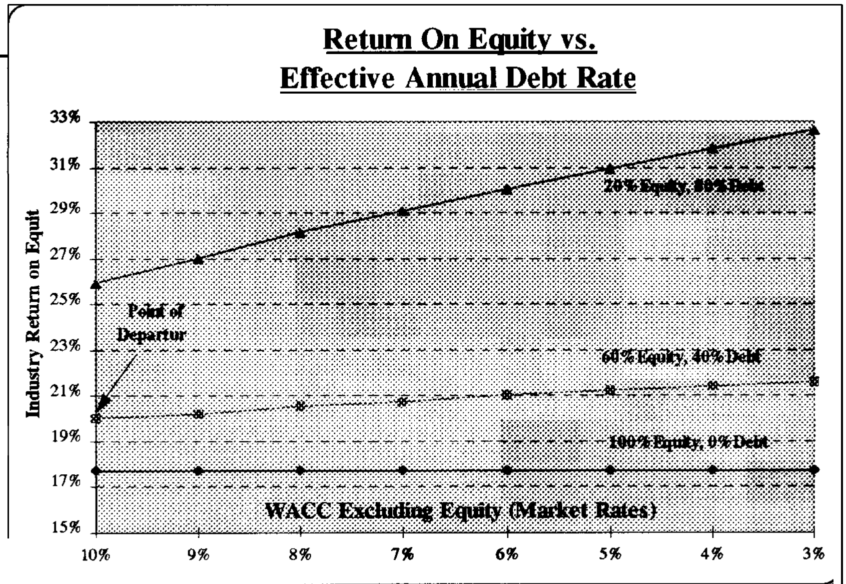

Figure 3: A Typical Graph of Sensitivity Analysis

In the RLV analysis, on the Industry side, early costs and revenues are more significant, because the relatively high ROR increases their effects. For example, when a standard industry practice of 50 % prepayment 6 months in advance is entered into the model, the whole revenue stream shifts up by half a year, and the ROR increases 1.6%. On the Government side, since MARR is relatively low, timing of expenditures is not as significant as their magnitude. The current strategy of technology investments now to reduce expenses later fits well with the Government's financial characteristics. In addition, the difference between the Industry and Government horizons suggests a promising strategy. If Industry needs to reach break-even in 15 years, and Government can wait, the optimal arrangement would be where Government incentives brought Industry to break-even quickly, but then Industry provided Government discounted launch rates to increase the ROR in the out years.

For the most positive view, examine your project from every angle. Probabilistic software can be used to model the uncertain variables in the project mentioned earlier, which yields a distribution of outcomes, rather than one deterministic answer. This more truly depicts what characteristics the outcome will likely take on. In any case, study the characteristics of your program, and choose areas of concentration that maximize your efforts to put your project's best foot forward.

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