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## Uncertainty, Risk and Investment Decisions

Joel S. Greenberg

*Director, Techno-Economic Analyses, ECON, Inc., Princeton, New Jersey*

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## UNCERTAINTY, RISK AND INVESTMENT DECISIONS

Joel S. Greenberg  
Director, Techno-Economic Analyses  
ECON, Inc.  
Princeton, New Jersey

### ABSTRACT

Many government-sponsored applied research, development, demonstration and incentive programs are specifically undertaken to develop technology or create an environment that will lead to commercial ventures which will be in the public interest. The current Administration's emphasis on commercialization has brought to the forefront joint endeavor or government/industry cooperative agreements and proposals for divesting operational capabilities to the private sector. The common thread between all these activities is the need for government agencies to plan and evaluate the private sector business ventures that may result. In the case of the joint endeavor agreements and divestiture situations, the evaluation of private sector business ventures is necessary to establish government negotiating positions.

This paper briefly summarizes private sector financial performance measures and shows how government actions can affect private sector investment decisions through a reduction in perceived risk and shifting the burden of funding from the private sector to the public sector. Data is presented that illustrates the functional relationship between likelihood of investment and expected return on investment, risk, payback period and exposure. Finally, the required public sector financial analysis in support of joint endeavor agreements and divestiture situations is examined. Many questions and issues are raised with general procedures developed to answer a number of these.

### INTRODUCTION

Many government-sponsored applied research, development, demonstration and incentive programs are specifically undertaken to develop technology or create an environment that will lead to commercial ventures which will be in the public interest. For example, much of the Department of Energy (DOE) effort is aimed at encouraging commercialization. Commercialization of new energy technologies is an important federal goal. Early NASA communication

satellite RD&D efforts also had such a purpose and led to the formation of the COMSAT Corporation and ultimately to a broad range of communication services provided by such companies as RCA, Western Union, AT&T and Satellite Business Systems. The Department of Transportation undertakes RD&D and other efforts to influence maritime related investment decisions. For example, programs are currently underway that seek to influence private sector investment decisions pertaining to new coal ports [1]. In addition, policies have been developed to provide tax credits as incentives to make energy conservation investments and to encourage business to invest in plant and equipment.

NASA's current space station efforts are also aimed at the private sector (as well as the public sector). The space station will permit entry of the private sector into space by providing a microgravity facility for developing and then manufacturing commercial products. Therefore the benefits to be derived from the development and use of the space station will, to a certain extent, depend upon private sector utilization of the space station. Other NASA efforts aimed at commercialization include the mobile [2] and 30/20 GHz [3] communication satellite programs. Both of these are demonstration programs aimed at influencing private sector investment or commercialization decisions through reduction of perceived risk and shifting some of the burden of funding from the private to the public sector. The planning of such development and demonstration programs requires that the public sector plan and evaluate private sector business ventures in order to assess the effect of these programs on private sector investment decisions.

The current Administration's emphasis on commercialization has brought to the forefront joint endeavor or government/industry cooperative agreements. These include NASA/industry cooperative space processing endeavors [4] and low earth orbit platform endeavors [5]. There has also been an ever increasing number of divestiture proposals from both the public and private sectors. These include NOAA's efforts to commercialize the LANDSAT and meteorological satellites [6,7], the

Space Transportation Company's [8] efforts to commercialize the Space Shuttle, and various proposals to commercialize the fleets of expendable launch vehicles. Commercialization through joint endeavor agreements or divestiture of government operations or assets requires negotiating with the private sector. In order for the public sector to establish its negotiating positions it is necessary that the public sector plan and evaluate private sector business ventures and understand private sector decision processes.

When government programs are undertaken with the specific intent of developing technology or creating an environment that will lead to commercial ventures, the desired benefits will not result unless private sector investment in business ventures results. Under these conditions it is necessary for the public sector to plan and evaluate private sector business ventures so that the specific impact of the government programs on investment decisions can be assessed. For programs aimed at influencing private sector investment decisions, there can be no benefits unless private sector investment decisions are altered as a result of the public sector programs. This paper deals with such situations and illustrates how the public sector can explicitly take into account in its benefit-cost analysis the likely effect that its programs and policies will have on private sector investment decisions. In so doing, the public sector can identify programs and policies that are more likely to achieve desired goals.

It is argued that the public sector can influence private sector investment decisions through a reduction in private sector perceived risk and/or shifting the burden of funding from the private to the public sector. Since risk reduction has a major effect on investment decisions, it is necessary to perform financial risk analyses. Risk analysis techniques are therefore described. Data is presented which shows that the likelihood of private sector investment is a function of expected return on investment, variability or standard deviation of return on investment, expected payback period and expected maximum exposure. Thus the impact of government programs and policies must be developed in terms of these variables so that the consequences can be assessed in terms of changes in the likelihood of private sector investments. Public sector benefits are directly related to the change in investment likelihood that is the result of the public sector programs or policies.

Finally, joint endeavors or cooperative government/industry agreements and divestiture situations are discussed. A number of issues are raised and it is argued that it is necessary for the public sector to plan and evaluate private sector business ventures in order to formulate negotiating positions that will achieve desired objectives.

Before embarking on a discourse of public/private sector interactions, it is necessary to have a clear understanding of several financial performance measures that are important in private sector decisions. After-tax profit is the difference between revenues and expenses and less taxes. The taxes are a function of revenues and expenses, carry-forward losses and investment and other tax credits. Capital expenditures are not explicitly included in the profit computation, but occur indirectly (and in any one year only partially) through the depreciation expense. Depreciation is an allowed expense which accounts for the wearing out of capital assets. Cash flow indicates the flow of funds through the business venture. The cash flow computation includes the magnitude and timing of the inflow and outflow of funds. It includes such measures as after-tax profit, depreciation, capital expenditures and the change in balance sheet items such as accounts receivable, accounts payable and inventory. Indebtedness is defined as the negative of the cumulative cash flow to any point in time. When indebtedness is positive, cash outflows have exceeded cash inflows and the total investment has not been recovered. When indebtedness is negative, the cumulative cash inflow exceeds the cumulative cash outflow. The peak of the indebtedness curve indicates the maximum funding requirement of the business venture. The point in time at which the indebtedness passes through zero is the payback period and indicates the time it takes to recoup the investment. These definitions are illustrated in Figure 1. Figure 2 illustrates simplified profit and cash flow computational procedures.

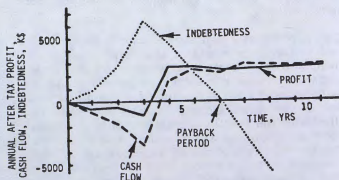


FIGURE 1 ANNUAL AFTER TAX PROFIT, CASH FLOW AND INDEBTEDNESS

The present value (PV) of a business venture is the summation of the stream of cash flows discounted to the present according to

$$PV = \sum_t \frac{\text{Cash Flow}_t}{(1 + \frac{r}{100})^t}$$

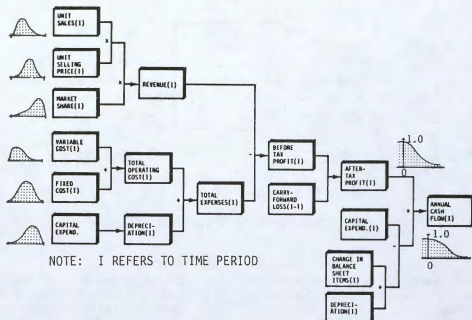


FIGURE 2 SIMPLIFIED PROFIT AND CASH FLOW COMPUTATIONAL PROCEDURE

where  $r$  is the discount rate or cost of capital. The return on investment, ROI, is the value of the discount rate that yields a present value of zero. In other words, the ROI is the rate of return at which the time adjusted value of cash outflows is equal to the time adjusted value of cash inflows. If the ROI exceeds the cost of capital it is desirable to pursue the business venture. Frequently, a threshold or cutoff rate of return or hurdle is established above the cost of capital. This hurdle rate, which must be exceeded by the venture's ROI, is a typical approach used to "compensate" for risk.

The evaluation and planning of new business ventures by the private sector is concerned with determining sales potential, profit potential, required investment (exposure), when investment will be returned, cash flow, present value of cash flow, expected rate of return, risk and many other factors. Their determination is based upon delineating R&D, operating, engineering, manufacturing and other costs and expenditures. It is also important, particularly in a new business venture based upon new technology and new services, to explicitly consider uncertainty and resulting risk [9,10]. Uncertainty refers to the subjective assessment of the variability (i.e., a probability density function) of basic parameters, such as the number of customers for a specific good or service as a function of time; and risk refers to the chance that various performance measures exceed different levels. In the following a specific measure of risk, the standard deviation of ROI, is considered.

Figure 2 illustrates the profit and cash flow computations, taking into account uncertainty in the input data—that is basic input parameters such as unit sales, selling price, market share, etc., are described in the form of range of uncertainty and the

form of the uncertainty (i.e., probability density function). The profit, cash flow and other financial performance measures are therefore describable as probability distributions—a convenient form is that of the "risk profile" as indicated in Figure 2. The risk profiles (i.e., complement of the cumulative probability distribution) indicate the chance that the performance measure will exceed different levels.

To transform the uncertainty profiles into risk profiles requires the use of a financial simulation or risk analysis model. The concept of risk analysis—a formal procedure whereby quantitative estimates of uncertainty associated with basic input quantities are converted to risk profiles of performance measures—is illustrated in Figure 3. In the simplified model shown in Figure 3 revenue (in the  $I^{th}$  time period) is equal to the product of unit sales, selling price and market share; before-tax profit is equal to revenue less the sum of all expense items less the depreciation expense; after-tax profit is one minus the tax rate multiplied by the before-tax profit.

The risk analysis [9-12] is performed by random sampling of the input data (according to the weighting of the uncertainty profiles), performing the computations contained within the simulation model, saving the results and thence repeating the process. This process is repeated a large number of times (Monte Carlo) until a reasonable set of histograms can be developed from the saved output data. These histograms are thence manipulated into the desired form so as to indicate the variability of pertinent performance measures such as profit, cash flow, indebtedness (negative of the cumulative cash flow to date), rate of return and present worth. A convenient form of displaying the performance measures is that of the "risk profiles" which indicate

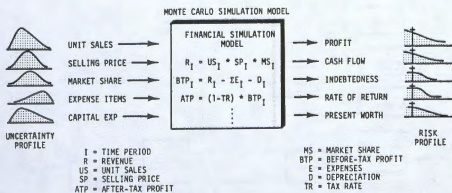


FIGURE 3. THE CONCEPT OF RISK ANALYSIS

the chance of the performance measure exceeding specific levels (i.e., the complement of the cumulative probability distribution).

To establish the risk profiles, the uncertainty profiles associated with the basic input parameters must be established. Informed estimates need to be made of the ranges of uncertainty of key variables and their probability distributions within the ranges. The uncertainty assessments can be made by individuals, or they can be made by an experienced group of individuals using Delphi-type techniques.

These uncertainty estimates are very subjective and so quantitatively express the attitudes regarding uncertainties—reflect past experience with similar efforts, typical problems encountered in the past, insights into problem areas which might develop, etc. The uncertainty profiles, being subjective estimates, call for expert opinion in each area. Manufacturing personnel should make the estimates of the uncertainty surrounding manufacturing cost; marketing personnel should make the estimates of the uncertainty surrounding the sales forecast and marketing costs; and so on in every category of input. Risk analysis demands detailed knowledge of the factors being evaluated!

A useful and frequently used procedure for establishing the shape of the uncertainty profile might be outlined as follows (see Figure 4):

- A. Estimate the range of uncertainty—minimum and maximum bounds (little or no chance of falling outside these bounds). Divide this range into a number of equal intervals—five has been found, through experimentation, to be useful.
- B. Make a relative ranking of the likelihood of the variable falling into each of the intervals; this establishes the general shape of the uncertainty profile (i.e., skewed left, central, etc.).

- C. Set relative values for the chance of falling into each interval. (For the Figure 4 case, the chance of falling into interval 1 is half that of falling into interval 2).
- D. Having assumed the possibility of falling within the range of uncertainty as 1.0, the chance of falling in each of the five intervals can be summed and set equal to unity. This equation can be solved (by substituting the relative values as obtained in paragraph C) for the probabilities associated with each interval.

This can become a long procedure when a large number of uncertainty variables and/or a large number of time intervals must be treated for which assessments have to be made. To minimize this problem, a large number of uncertainty profiles are stored in the computer and pictures of these shown

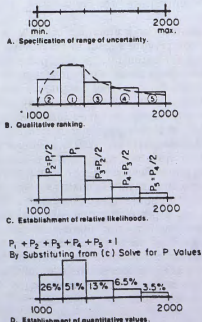


FIGURE 4. A METHODOLOGY FOR ESTABLISHING UNCERTAINTY PROFILES

to the evaluators. The evaluator then need specify only the minimum and maximum values and the name of the applicable uncertainty profile. If the appropriate uncertainty profile has not been stored, it can be created by the process just outlined.

Using the risk analysis technique, risk profiles may be developed for performance measures such as profit, cash flow, cumulative cash flow or indebtedness, payback period, return on assets, and return on investment. Figure 5 shows typical risk profiles of ROI. The vertical scale represents the probability (chance),  $p$ , of exceeding the various levels of ROI, indicated by the horizontal scale. In general, the steeper the curve, the lower the risk (or variability). When comparing alternatives, it is important to compare the expected or "most likely" ROI values. It is equally important to compare risk levels. (Note that, as per the central-limit theorem, the expected and "most likely" values of ROI are equal).

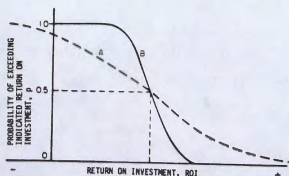


FIGURE 5 TYPICAL RISK PROFILES OF RETURN ON INVESTMENT

Figure 5 illustrates the ROI risk profiles for hypothetical alternatives, A or B. A decision maker performing a conventional analysis usually evaluates quantitatively on the "most likely" return on investment. To this uninformed decision maker, alternatives A and B "look alike" because they show equal ( $p = .5$ ) expected and "most likely" values.

In conventional analysis, the decision maker will try to pick the alternative yielding maximum ROI or other performance measure. In risk analysis the selection process is more difficult. Tradeoffs must be made between alternatives possessing different expected present values and associated levels of risk. When the risk dimension is added, the decision maker finds alternatives A and B in Figure 5, for instance, quite different. Alternative A assumes greater risk (variability) than Alternative B. Thus a conservative decision maker (averse to risk) would normally select B (if he does not feel other, unquantified pressures to select alternative A).

The following paragraphs discuss the typical tradeoffs that are made with respect to risk (as measured by the variability or standard deviation of ROI), expected ROI, payback period and magnitude of the investment (i.e., exposure).

In many instances the individual or group of individuals that is responsible for planning and evaluating a development, demonstration or incentive program does not have control of the investment decisions that must be made in order to capitalize upon this work. Yet in justifying the program it is necessary to establish a value for the program which derives from altering investment decisions that are beyond the planner's control. Since in the planning process it is not possible to know what future investment decisions will be with certainty, the future investment decisions can only be described and considered in terms of the likelihood or chance that they will be made. Thus, the XYZ Company considering a synfuel demonstration facility should not take it as a foregone conclusion that an operational facility will be implemented if the demonstration is a success. The likelihood of a decision to implement an operational facility will be a function of pro forma performance measures such as annual profit, time of profitability, return on investment, payback period, magnitude of investment, risk and others. A government agency such as NASA considering donating a Space Shuttle flight as part of a joint endeavor agreement should not take as a foregone conclusion that the private sector will make additional investments necessary to establish an ongoing business venture. The value of the NASA program should consider the likelihood that the private sector will make these investments where the likelihood is a function of pro forma performance measures such as profit, return on investment, payback period and others.

Important determinants of private sector investment have been found to be expected value,  $m$ , and variability (risk),  $\sigma$ , of return on investment, ROI, expected payback period and expected exposure. To measure the functional relationship that exists in practice—the key to establishing the effect of risk and other financial performance measures on investment decisions—a survey of executives was conducted under the auspices of the American Management Associations [13]. Persons queried had the titles of Vice President, Finance; Controller; Treasurer or Director of Corporate Planning. The results of the survey are illustrated in Figures 6, 7 and 8 where expected ROI, risk (i.e., the standard deviation of ROI), payback period and exposure (the ratio of the maximum funding required to the budget of the decision makers).

Figure 6 illustrates the investment likelihood for the manufacturing sector. The specific set of curves is for a four year payback period and an investment that is between 1 and 10 percent of the capital budget. The scales are normalized to the firms' cost of capital. Thus the vertical scale represents the expected ROI as a fraction of the cost of capital (1.0 indicates that the ROI is equal to the cost of capital). The horizontal scale represents the risk or standard deviation of ROI as a fraction of the cost of capital. The curves represent contours of equal

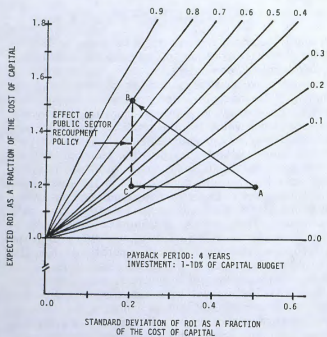


FIGURE 6 INVESTMENT LIKELIHOOD IN TERMS OF EXPECTED ROI & RISK

likelihood or probability of investment. The line marked 0.8 indicates that those investments that are characterized by points  $(m, \sigma)$  that fall on this line have, a priori, an 80 percent chance of receiving funding. There is an 80 percent chance of an investment when the decision makers perceive an expected ROI that is 1.5 times the cost of capital and a level of risk (standard deviation of ROI) that is 0.2 times the cost of capital (see point B in Figure 6). Point A represents the expected ROI and standard deviation that would result in the absence of the development or demonstration program. Points B and C result from the pursuit of different development or demonstration programs. More will be said about this in following paragraphs.

Since all points that fall on the same contour have an equal chance of being funded, the contours indicate the general risk avoidance preferences of an industry sector.

Figures 7 and 8 summarize the investment likelihood in terms of magnitude of investment and payback period. It should be noted that there is a very definite rotation of the curves in terms of both investment magnitude and payback period. The rotation indicates the risk avoidance preferences in terms of payback period and investment magnitude, i.e., small expenditures and short payback period investments obviously have the highest likelihood of being funded. The curves indicate these risk-avoidance preferences quantitatively.

The significance of the investment likelihood curves as a function of financial performance measures can be grasped by noting that the expected benefits, B, from a public sector program undertaken to influence private sector investment decisions is given by

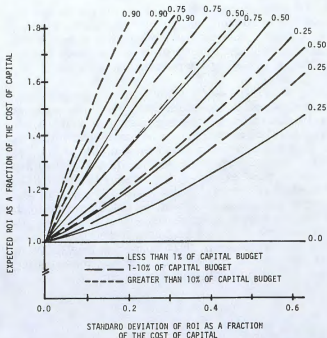


FIGURE 7 EFFECT OF INVESTMENT MAGNITUDE ON INVESTMENT LIKELIHOOD IN TERMS OF EXPECTED ROI AND RISK--4 YEAR PAYBACK

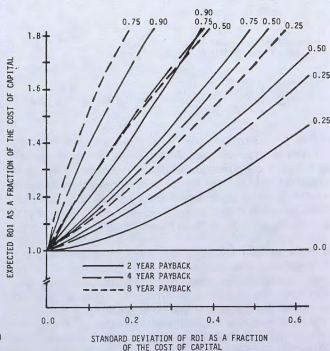


FIGURE 8 EFFECT OF PAYBACK ON INVESTMENT LIKELIHOOD IN TERMS OF EXPECTED ROI AND RISK--INVESTMENT IS 1-10% OF CAPITAL BUDGET

$$B = \alpha_B \times NPV_B - \alpha_A \times NPV_A - PVC$$

where  $NPV_B$  and  $NPV_A$  are the expected public sector net present value of benefits with and without the development, demonstration or incentive

program respectively. The values of NPV<sub>A</sub> and NPV<sub>B</sub> can be determined using benefit-cost analysis to establish public sector benefits. PVC is the expected present value of the cost of the public sector program.  $\alpha_B$  and  $\alpha_A$  are the probabilities of private sector investment with and without the public sector program respectively as obtained from the investment likelihood curves. It is immediately apparent that the difference between  $\alpha_B$  and  $\alpha_A$  has a major effect on public sector benefits. It is also evident (from Figure 6) that the value of  $\alpha$  should not arbitrarily be taken as 1.0 with the public sector program and 0.0 without the public sector program. The appropriate value of  $\alpha$  can only be established by planning and evaluating private sector business ventures explicitly taking into account quantitative estimates of uncertainty and the effect of the public sector program on these uncertainties. The overall evaluation procedure is summarized in Figure 9 where the assumed impact of the public sector program is a reduction of the uncertainty associated with sales.

To summarize, public sector development, demonstration and incentive programs are undertaken to 1) reduce performance uncertainty, 2) reduce cost uncertainty, 3) reduce market uncertainty, and 4) reduce private sector exposure (the maximum required investment as indicated by the peak of the indebtedness curve—see Figure 1). The impact on the private sector is through a reduction in private sector perceived risk and/or exposure with the increased likelihood of the private sector developing and marketing beneficial goods and/or services. Risk analyses must be performed to obtain the financial performance measures that are necessary to establish the investment likelihood.

The typical effect of a demonstration program is illustrated in Figure 10 in terms of the performance measures previously defined. Figure 10A illustrates the effect of full investment, including the demonstration program, by the private sector. The degree of variability of exposure (maximum of the indebtedness curve), payback period and ROI is indicated. A large part of the variability is due to the uncertainty of the cost and outcome of the demonstration program. Figure 10B illustrates the impact on the private sector of NASA undertaking the demonstration satellite program with no transfer payment from the private sector to NASA. Note that private sector exposure is reduced as is the variability of exposure, payback period and ROI. At the same time the expected ROI is increased. This is due to the uncertainty in the cost and outcome of the demonstration program being eliminated (private sector decisions can await the outcome of the NASA program) as well as the private sector demonstration program funding requirement being eliminated. Figure 10C indicates the impact of a NASA demonstration program when a payment is made to NASA from the private sector for using the resulting demonstration satellite in an operational system. The impact of the payment is to increase expected exposure and payback period and to reduce expected ROI. Note that there is no change (relative to

Figure 10B) in the variability of the performance measures. It is obvious that the business venture under scenario B is more desirable than under scenario C, which is more desirable than under scenario A. It is also obvious that the course of government action can affect the likelihood of the private sector undertaking the hypothetical business venture. Since NASA benefits are a function of private sector investment decisions, NASA benefits will differ for each of the scenarios.

The impact of risk, expected ROI, payback and exposure is illustrated in Figure 6 in terms of the likelihood of private sector investment,  $\alpha$ . The three alternatives shown in Figure 10 are indicated in Figure 6 as the previously discussed points A, B and C and demonstrate the role of the public sector in affecting private sector investment decisions through perceived risk reduction and shifting the burden of funding from the private to the public sector. It should be noted in passing that the effect of a recoupment policy (i.e., payback to NASA for service rendered) is to drive point B toward point C and thus reduce the likelihood of private sector investment. It is, of course, desirable for a government agency to be paid for services rendered, but this must be tempered by its effect on total benefits—the true objective is maximization of benefits.

#### SOME COMMERCIALIZATION ISSUES

The current Administration is placing increased emphasis on commercialization of space systems and technologies. This has led to government agencies, NASA and NOAA in particular, into a new arena—the planning and evaluation of private sector business ventures and the entering into joint endeavor or government/industry cooperative agreements and the divestiture of government assets and capabilities to the private sector. Currently under consideration or in force are NASA/industry joint endeavor agreements concerning space processing ventures and a small low-earth orbiting platform business venture. Divestitures currently under consideration includes the Delta, Atlas/Centaur and Space Shuttle Transportation systems and the earth observation and meteorological satellite systems. Each of the joint endeavors requires the participating government agency to provide a service or make a commitment such as a guarantee to utilize a product or service. This is undertaken with the objective of inducing the private sector to make investments that will lead to business ventures in the public interest—that is, to achieve benefits from the government programs. Divestitures are considered when the private sector is capable and interested in providing services that have previously been provided or developed by a government agency. This may or may not be accomplished more effectively by the private sector, but the private sector desires to try.

Turning attention to joint endeavor or cooperative agreements, it is the purpose of these agreements to



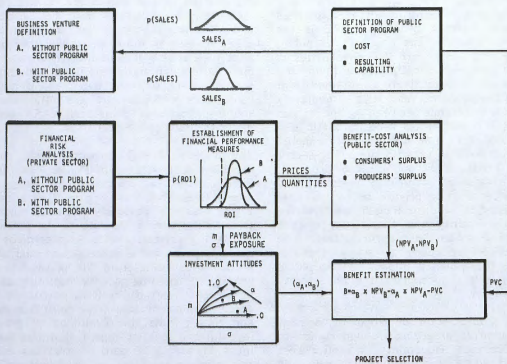


FIGURE 9 GENERAL PROCEDURE FOR EVALUATING THE BENEFITS OF A PUBLIC SECTOR PROGRAM IN SUPPORT OF THE PRIVATE SECTOR

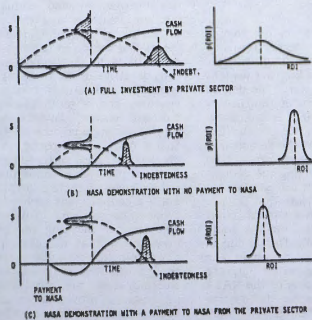


FIGURE 10 IMPACT OF A DEMONSTRATION PROGRAM ON THE PRIVATE SECTOR

effect private sector investment decisions through risk reduction and/or shifting the burden of funding from the private to the public sector. Using NASA as an example, NASA is normally expected to contribute in the form of providing launch and related services with payment foregone or delayed, or to commit to the partaking of services or products to be offered by the private sector business venture. Note that the former contribution results in increasing expected ROI, reducing payback period and reducing the exposure by shifting the burden of funding from the private to the public sector. The latter contribution results primarily in reducing perceived risk by reducing market uncertainties.

There are many questions that should be answered concerning proposed joint venture agreements among which are the following. Does the contemplated private sector business venture (that will result from the agreement) make financial sense without the NASA commitment? With the NASA commitment? What is the chance that the private sector will initiate the business venture without the NASA investment? With the NASA investment? Does the change in the investment likelihood warrant the commitment requested of NASA? Are the resulting benefits to NASA worth the NASA "investment"? In order to answer these types of questions it is often necessary to perform an independent assessment of the proposed business ventures. This entails, in some cases, independent market assessments and sales forecasts and the formulation of a business venture including estimates of revenues, expenses, costs and capital expenditures. A typical assessment of a proposed joint endeavor agreement

concerning a low-earth-orbiting spacecraft business venture such as LEASECRAFT [5] is illustrated in Figure 11. The objective of such analyses are to establish NASA negotiating position with respect to what it can afford (as well as the form) to give up in order to effect the proposed venture. For example, a hypothetical situation is shown in Figure 12 and illustrates the effect of a donated Space Shuttle flight and guarantee to limited purchase of services—the former effects expected ROI and the latter effects perceived risk. In the hypothetical example both yield a 50 percent chance of private sector investment but the former is accompanied by a cost. The latter situation is therefore preferred.

As already pointed out many divestiture situations are developing. However there are not many examples in the U.S. of the planned divestiture of public sector capabilities to the private sector. In the private sector a divestiture often represents an attempt to improve cash flow or to realign corporate capabilities with new business objectives. In the case of the public sector divestiture, it is important to understand and quantify the benefits to the public of the proposed transfer. Moreover, in some cases the government will continue (at least for some period of time) to purchase some part of the services provided by the new private sector venture. For example, in the event of the divestiture of weather or earth observation space systems, the government would undoubtedly be a major purchaser of data products.

Again using NASA as an example, proposals are currently evolving by the private sector to commercialize various aspects of the Space Shuttle

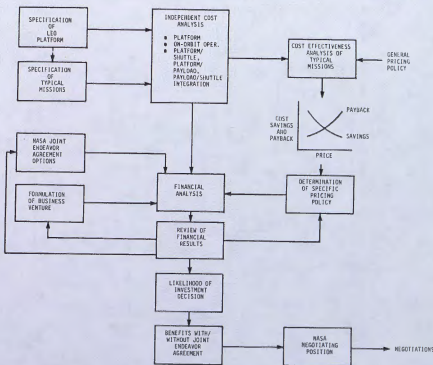


FIGURE 11 TYPICAL ASSESSMENT OF A JOINT ENDEAVOR AGREEMENT

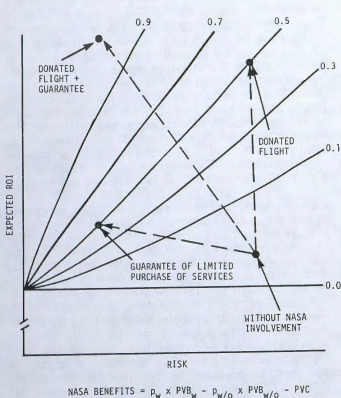


FIGURE 12 AN EXAMPLE OF THE EFFECTS OF ALTERNATIVE NEGOTIATING POSITIONS ON INVESTMENT DECISIONS

Transportation System as well as the expendable launch vehicles (ELV). These proposals are likely to suggest that NASA facilities and/or people be transferred to or perform services for the proposed ventures. What should NASA be paid for lease or transfer of facilities, people and/or services? What will be the pricing policy of the proposed venture and what effect will it have on the cost of NASA missions? What effect will the pricing policy (for example, a commercialized Delta launch vehicle) have on the utilization and hence the pricing of the Space Shuttle? What happens if the business venture (i.e., the commercialized launch vehicles) is not profitable? Is the transportation capability lost, or is there an implied NASA guarantee for continuity of service? If failure of the business venture is due to competitive forces, does this imply the lack of need for the specific launch vehicles? Will private sector goals and objectives be similar to those of NASA (this is extremely important if the divestiture is not of the complete system)? If not, what problems are likely to arise?

In order to answer questions such as these, government agencies must perform analyses such as indicated in Figure 13. At the heart of this is a financial analysis of the proposed business venture. The financial analysis, if performed parametrically in terms of pricing policies and recoupment policies, can shed light on the government agencies' appropriate negotiating positions.

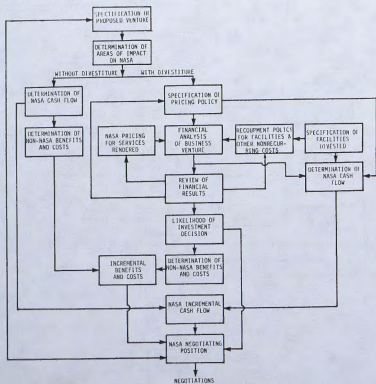


FIGURE 13 TYPICAL ASSESSMENT OF DIVESTITURES

The subject of commercialization cannot be closed without a comment on government subsidization. Irrespective of a common belief there is indeed a place for subsidization if the subsidization will alter private sector investment decisions to initiate business ventures that will produce public or societal benefits that exceed the cost of the subsidization. Subsidization has a place when a pricing mechanism does not exist for the services rendered. For example, consider the provision of improved emergency medical communications services via satellite. It has been shown that thousands of trauma victims lives could be saved annually from improved EMS communications—this, if converted to a dollar value, is equivalent to many hundreds of millions of dollars per year. A commercial business venture to provide these services would, however, have revenue based upon the number of telephone calls, their duration and price. In short there is no viable pricing mechanism that can be related to the value of a human life saved as a result of the improved EMS communications. Thus large societal benefits have been foregone because the private sector has not found a mechanism to provide profitable EMS communication services—it is possible that subsidization could alter this.

#### SUMMARY

With the increasing emphasis being placed upon commercialization of space systems and technologies, it is necessary for government agencies to develop new skills and techniques in order to perform the required assessments and evaluations. As joint endeavor and divestitures are proposed it is necessary for government agencies to establish the desirability of the proposals and to establish the appropriate role of the government agencies in the proposed endeavors and divestitures. In many instances the contemplated role is that of providing incentives in the form of donated Space Shuttle flights or guarantees to utilize the provided products or services. In other cases the contemplated role is that of providing facilities, personnel or services. What is appropriate in order to increase the likelihood of commercialization and achieve the desired benefits?

To answer the foregoing question requires that the government agencies plan and evaluate private sector business ventures. It is through the analysis of the business ventures that the impact of alternative government actions can be determined. In essence, the government agencies perform financial analyses to establish their negotiating positions.

Public sector actions can effect private sector investment decision by reducing perceived risk and shifting the burden of funding from the private to the public sector. The likelihood of private sector investments is a function of many financial performance measures. Quantitative data has been presented that shows the functional relationship between investment likelihood and expected ROI, risk (standard deviation of ROI), payback period and

exposure. This quantitative data is the link between public sector actions and private sector investment decisions.

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