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A Model for Laboratory Tech Transfer Investment

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Abstract

A simple model has been developed to address a pragmatic question: What fraction of its research and development budget should a national laboratory devote to enhancing technology in the private sector? In dealing with lab-wide budgets in an aggregate sense, the model uses three parameters – fraction of lab R&D transferable to industry, transfer efficiency and payback to laboratory missions – to partition fixed R&D resources between technology transfer and core missions. It is a steady-state model in that the transfer process is assumed to work in equilibrium with technology generation. The results presented should be of use to those engaged in managing and overseeing federal laboratory technology transfer activities.

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1. Introduction

Amidst the debate on the importance of industrial competitiveness to the well-being of the country in a global economy and the proper role of the government in furthering competitiveness, lies a question requiring a pragmatic answer: What fraction of the research and development (R&D) budget at a national laboratory should be devoted to enhancing technology in the private sector? The answer can obviously be dictated by national policy: little or none at one extreme; almost all at the other.

Today's reality suggests, however, that the United States is not willing to support a massive laboratory system providing federally-funded R&D to the private sector upon demand. On the other hand, President Clinton, with Congressional support, envisions the federal labs making a significant contribution to U.S. competitiveness and devoting 10 to 20 percent of their existing budget to joint ventures with industry.¹

The National Academy of Engineering, in addressing both goals for national technology policy and promising paths along which to pursue those goals, did not place much emphasis on contributions from federal laboratories. Their report stated:

*"The recent proliferation of Cooperative Research and Development Agreements (CRADAs) between federal laboratories and private companies or consortia may help some of the participating federal laboratories develop greater competence in industrially relevant work. To the extent these public-private partnerships do not detract from the core R&D mission of participating federal laboratories, and meet the same criteria for other more direct federal subsidies of precompetitive R&D...their creation should be encouraged. However, since it is too early to judge the overall effectiveness of CRADAs, the committee believes federal funding of mission-oriented laboratories for commercially relevant R&D should be approached with caution and in an experimental mode with periodic review to appraise its economic impact."*²

Neither the President's vision of the federal labs making significant contributions to U.S. competitiveness nor the more cautious recommendations of the National Academy of Engineering has been fully accepted. Some believe that the importance of competitiveness itself has been overstated: "that competitiveness is a meaningless word when applied to national economies."³ Others advocate government support but stress direct government investment measures for advancing R&D responsiveness "to the changing needs of the different [industrial] sectors."⁴

Given these conflicting views, it is not difficult to understand the emphasis on finding a strategy which supports both the missions of laboratories and the process needed to assist the private sector in enhancing its industrial competitiveness. The proposed solution centers on technology transfer: the process of taking scientific, engineering and technical know-how, and intellectual property and transforming this knowledge into processes, products and

services for commercial applications. It began in earnest with the passage of the Federal Technology Transfer Act of 1986, was accelerated by the National Competitiveness Technology Transfer Act of 1989, was fostered during the Bush administration and is receiving greater attention today.

The Department of Energy (DOE) Strategic Plan⁵ calls for developing integrated R&D program plans with industry and maximizing R&D partnerships across DOE through co-planning and co-funding. Even this integrated R&D approach cannot be implemented without additional cost or adjustments in mission responsibilities. Some R&D is simply too mission-specific to be of use to industry. Some technologies will require significant investment for adaptation to expressed industrial needs. But, with careful planning, many activities may be sufficiently well aligned to benefit both laboratory mission and private sector needs without much additional cost to the government.

In a recent DOE-sponsored survey,⁶ which examined industry-federal laboratory interactions, including activities well beyond efforts to transfer licensable technology, more than 70 percent of the private sector laboratory and division directors indicated that cooperative research holds the most promise for their organizations. Of the other nine ways of interaction considered, the next most popular were workshop/seminars, lab visits, technical consultation and contract research, each receiving votes from about 40 percent of the directors.

Of the most promising activities, CRADAs are likely to dominate in terms of impact on laboratory mission resources.^{*} The others are relatively inexpensive. CRADAs, however, can consume a fair fraction of laboratory R&D resources. If the federal laboratories are held to mission-consistent CRADA activities and industry partners are required to invest matching funds, natural forces begin to limit the magnitude of the commitment. Even under these constraints there is still a danger that technology transfer can crowd out the principal source of the technology base that CRADAs draw upon: mission-oriented R&D.

A relatively simple model can provide insights into technology transfer investments. But before work on a model was started, it was helpful to agree upon a fundamental premise: **the value of the technology transferred from the federal laboratory is the cost that would be incurred by the industrial partner developing or acquiring the technology without federal lab participation.** This metric is very different from the sales or profit that the industrial partner might eventually realize or the resources expended by a government lab to develop the technology. Consider the cases shown in Table I. Technology transfer from a

^{*} Most program offices supporting CRADAs require the industrial partner to invest in-kind resources comparable to the federal funds committed by the laboratory partner. Federal funds cannot be transferred to the industrial partner, but industry funds and other resources can flow into the laboratory. Typically, each party funds activities within its own organization.

federal lab is attractive only when there is a significant potential benefit to the industrial partner. Further, if the ratio of the value of technology transferred to the cost to transfer is low, there are incentives for the industrial concern to prefer private industry R&D. Government help, with attendant complications, is not likely to appear attractive. This leads to the observation that potential profit from the application of R&D determines whether or not the R&D gets done. It does not, in general, determine who does the R&D. What the R&D will cost the industrial concern will be the determining factor in deciding who does it.

Table I

Industrial Partner Likely Response

		Ratio of R&D Value to TT Cost	
		High	Low
Potential Benefit of R&D to Industrial Partner	High	TT is the most attractive option.	May prefer In-house R&D to TT to increase control.
	Low	Not likely to use TT. Low payoff.	Not likely to use TT. Low payoff.

- Definitions: 1. Value of R&D - Cost to industrial partner to develop or acquire the technology without federal lab participation.
2. Benefit of R&D to Industrial Partner - Ratio of expected profit to value of R&D.

To illustrate, suppose an industrial concern needs a new welding process and that developing that process in-house is estimated to cost \$100,000. If, however, for an investment of \$10,000, the welding process could be adapted from laboratory mission-oriented R&D through a CRADA, the industrial concern could avoid a cost of \$90,000. The ten-to-one ratio of R&D value to tech transfer cost places this transaction in the left (High) column in Table I, making it a candidate for implementation if the industrial partner judges potential benefits to be sufficient.

While this technology item has a current value of \$100,000 to this industrial partner, it is worth noting that:

- it may have cost the government far more or less to develop originally;
- its value may be quite different to other industrial concerns; and
- its past and future value to even this industrial concern may vary widely.

Like potential benefit, R&D value must be judged by the industrial partner and is also subject to uncertainties.

Consequently, the model developed in the next section uses neither potential commercial benefits nor R&D value (as previously defined) in allocating resources.^b Instead, the model is designed to apportion government laboratory R&D resources between mission-related R&D and technology transfer in an aggregate way, facilitating the latter without crowding out the former.

^b Those responsible for defining and carrying out technology transfer activities must strive to understand industry views on both potential benefits and R&D value using, for example, industry technology road maps in order to align mission R&D to the extent practical.

2. The Model

The model developed in this section deals with the technology transfer process at the individual federal laboratory level. The intended utility is a general understanding of suitable technology transfer investment considering that the laboratory has definite mission responsibilities, that tech transfer investments cannot always be directly aligned with lab missions, and that the two activities compete, to some extent, for lab R&D resources.

A simple three parameter, aggregate, steady-state model with many simplifying assumptions is used. It is an aggregate model in that it addresses lab-wide, not individual program, budgets. The steady-state aspect ignores the potential of an initial flood of technology from the lab and considers an equilibrium condition independent of when a technology is developed or transferred. There is an implicit assumption that the transfer process can proceed indefinitely.

The parameter k represents the fraction of the laboratory R&D transferable to industry, and arises from recognition that all R&D at a government lab is not suitable for commercial application. This parameter can be expected to vary from lab to lab depending on specific mission assignments and the details of how those assignments are executed. "The challenge is not to decide between doing a scientific mission or technology transfer, the challenge is to design-in credible technology transfer opportunities and commercialization potential as part of the program and institutional process."⁷ Successful implementation of this philosophy can increase the value of k without sacrificing mission performance.

The parameter B is a measure of the efficiency of the technology transfer process for a laboratory. It is related to the incremental cost to transfer the technology developed by the expenditure of a dollar on mission-oriented R&D.

The parameter c accounts for "payback" a laboratory gets from tech transfer investments. It represents that portion of the investment in technology transfer which generates R&D results relevant to the laboratory mission.

Step 1: Effect of Fixed Budget^c

A key assumption used in the development of this model is that the sum of dollars spent on tech transfer and mission R&D is fixed. The question addressed by the model is how to partition that budget between mission-related R&D and technology transfer. Figure 1

^c Budget connotes dollars, but on-roll technical personnel is often the most rigidly controlled resource at a federal lab. Converting the model from dollars to technical full-time equivalent personnel is a straight-forward exercise.

shows this effect graphically. The more money spent on tech transfer, the less that is available for developing technology which might be available to transfer. In this and the next few figures, the letter A is used to represent the total laboratory R&D budget.

This zero-sum notion overlooks several factors. The most important – payback from technology transfer to mission R&D – will be accounted for in Step 6. Other, less tangible factors are, unfortunately, not included; they are too difficult to quantify. For example, improved public relations and goodwill generated with industrial concerns and the public at large are not represented. Benefits of this type can be of real value in securing Administration and Congressional support, accomplishing mission-related tasks, recruiting personnel, etc.

Step 2: Effect of Non-Transferable Technology

Some portion of a laboratory's R&D will have no application in industry, and so not all of the budget invested in laboratory R&D creates transferable technology. The model assumes that the fraction of R&D applicable to industry is constant as technology transfer investment is varied. This is shown graphically in Figure 2 which introduces the parameter k , representing the fraction of lab R&D that is transferable.

Also introduced on this figure is the independent parameter of the model, which is x , the fraction of the total budget A that is invested in tech transfer. This parameter can take values between 0 (no investment in tech transfer) and 1 (the entire R&D budget is directed to tech transfer).

Combining these two parameters, it is seen that for any value of x , xA is the dollar amount spent on tech transfer, $(1-x)A$ is the amount spent on mission-related R&D, and $k(1-x)A$ is the amount of mission-related R&D that is actually transferable to industry.

Step 3: Effect of Transfer Efficiency

Transferring technology, which is in fact transferring knowledge, involves cost. For example, laboratory matching funds in the CRADA process, the overhead funds expended by the Tech Transfer Office, the efforts expended by laboratory staff members developing tech transfer proposals, and the lab investment in electronic hot lines or data retrieval systems for small business are all costs of transferring technology. For the purpose of this model, efficiency is defined as the ratio of the cost for the lab to develop the technology transferred to the actual cost to transfer the technology.

The incremental cost to transfer technology is likely to follow, in the aggregate, a law of diminishing returns. As a greater and greater fraction of the budget is invested in technology transfer, the incremental cost to transfer technology resulting from a dollar spent on R&D will increase. From a practical perspective, the diminishing returns occur if the lab first transfers technologies with highest leverage (perhaps those that find greatest applicability in industry) and the less leveraged technology only if the tech transfer budget is large enough. Alternately, the function can be viewed as representing, at any point in time, an efficiency rank-ordering of the tech transfer activities underway.

In the model, an exponential function⁴ was chosen to represent this effect for two reasons. First, the effect of diminishing returns can be represented by a single parameter; and second, the exponential parameter B is the initial slope of the transfer function and represents the upper bound on the efficiency. The parameter B can be thought of as the tech transfer leverage.

Step 4: Modeling Tech Transfer Effects

Combining (1) the effects of fixed total budget, (2) some level of non-transferable technology, and (3) the diminishing returns function results in the mathematical model shown in Figure 4. This figure is a plot of the amount of R&D transferred for the parameter values $k=0.8$ (80 percent of lab R&D is transferable to industry) and $B=20$ (efficiency characterized by an exponential with the most efficient activities requiring only one dollar to transfer technology resulting from 20 dollars of R&D). In this case, the dominant effect on the amount of R&D transferred for small investments in tech transfer is the transfer efficiency. The dominant effects beyond the peak in the curve are the fixed budget and level of transferable technology (k). For investments above 25 percent, the limit on technology transferred is the technology available to transfer.

An important consideration is the steady-state nature of this model. It is a single time frame model, with the implicit assumption that steady-state has been achieved and the transfer process can proceed indefinitely at the indicated rate. Any initial backlog of technology has already been transferred to industry, and the transfer process is working in equilibrium with technology generation.

⁴ The results are not particularly sensitive to the choice of an exponential. We believe it to be the best representation, but a linear function yields very similar results.

Step 5: Selecting an Investment Level

The model can be used to provide insight into investment levels consistent with economical technology transfer to industry. Theoretically a lab could operate at any point along the investment axis (i.e., the x axis). However, at points near zero, little or no technology will be transferred; at points near one, little or no new technology will be developed.

A reasonable investment strategy might be to increase tech transfer investment as long as that investment provides a positive incremental rate of return. Under this strategy, the lab would expand its investment in tech transfer until the incremental cost to transfer the technology exceeds the cost for the laboratory to develop the technology.

The vertical line in Figure 5 is drawn at the break-even investment point. It represents a particular level of investment in tech transfer and is divided into various segments by the different curves. The segment labeled "1" in the graph is the amount of technology actually transferred. The segment labeled "2" is the amount of additional technology available for transfer, but not transferred. The line segment marked "3" represents the technology developed which has no use in industry. The top segment, labeled "4" is the cost of tech transfer. This is an opportunity cost, and it represents the mission-related R&D not performed because of reductions in laboratory R&D investment to provide funding for tech transfer investment. Since the slope of the transfer curve is unity at this point, the vertical line is at the "positive incremental rate of return" investment limit. Beyond this point, it costs more than a dollar to transfer technology resulting from a dollar spent on mission R&D.

Selecting an investment level considerably less than shown in Figure 5 means that tech transfer is sacrificed for mission R&D. Selecting a considerably higher level of investment reduces both the transfer of technology and mission R&D. Figure 5 illustrates that it is better to err toward under investing than to significantly over invest.

Step 6: Effects of Tech Transfer Cost Recovery

Some fraction of the technical effort expended by both the lab and its industry partners will be relevant to solving mission-related problems. This alignment reduces the opportunity cost of tech transfer incurred by the lab. To account for this effect, a parameter c has been introduced into the model to represent the portion of the tech transfer cost which is recovered.

Figure 6 shows graphically the effect of c on the tech transfer process. The cost of tech transfer is divided into two regions, as shown. The region marked 4a represents the recovered cost, and the region marked 4b is the effective cost of tech transfer. It should be noted that the cost recovered from tech transfer does not add to the pool of transferable technology. Any R&D done in conjunction with industry is assumed to be "transferred."

However, recovered cost does reduce the effective cost of tech transfer; it reduces the denominator in the incremental rate of return calculation, effectively increasing the maximum investment level providing positive rate of return. (See Appendix 1.) The curve shown here assumes that 50 percent of the cost is recovered (i.e., $c=0.5$).

3. Results

The contour diagram in Figure 7 illustrates the effect of two of the parameters, B and k , on the maximum investment level for positive rates of return. The range selected in this and the following charts is not completely arbitrary. It is unlikely that a laboratory would conduct tech transfer if the efficiency of its most promising investments were much less than 10 to 1, and the chart was scaled to allow consideration of the interesting parameter range above this level. The curves on the figure link those points in B - k space which have the same value of the maximum investment level for positive incremental rate of return. The investment level is measured as a percent of lab R&D budget. For example, if $k=0.8$ and $B=20$, then the maximum investment level for positive return is about 12 percent of the R&D budget. A value of 50 percent for the recovery parameter ($c=0.5$) is used in this chart. One of the interesting insights that can be obtained from this chart is that for more than 80 percent of the space (for $B>10$, $k>0.1$), the optimal investment levels are between 5 and 20 percent.

Figure 7 underscores the variety of circumstances that can arise in assessing tech transfer investments for different laboratories. An R&D lab that emphasizes scientific research rather than engineering development may by its nature have a low value of k and a low value for transfer efficiency, B . As a result, its appropriate level for tech transfer investment could be quite different from that for a more applied laboratory. The chart also explains why different laboratories might have different emphases in tech transfer. The "optimal" investment level at a lab in which only 10 percent of the R&D is transferable is relatively small and is nearly independent of transfer efficiency, while the level for a lab at which 80 percent of the technology is transferable is much greater and may be somewhat sensitive to transfer efficiency.

Figure 8 shows the relative impact of tech transfer payback to laboratory mission R&D on the maximum positive incremental rate of return for tech transfer investment. The effect of increasing the tech transfer cost recovery factor is to increase the attractiveness of tech transfer investment. This effect is greatest in the lower right portions of the chart where there is high industrial applicability of R&D but low transfer efficiency. For example, considering $k=0.5$ and $B=10$, the maximum investment level increases from around 12 percent with tech transfer cost recovery to approximately 18 percent with a recovery level of 75 percent. By comparison, for $k=0.3$ and $B=0.2$, the investment level increases from roughly 7 percent to about 12 percent when the tech transfer recovery factor varies over the same range. For the bulk of the B - k - c space considered, maximum tech transfer investment levels are 20 percent or less.

4. Observations

In spite of its simplicity, the model lends insights regarding the competition for resources between technology transfer and mission-related R&D – the basic source for technology generation. Now that technology transfer has been pursued vigorously for five years or more and experience has been gained with many CRADAs and other transfer mechanisms, it should be possible for each laboratory to make first order estimates of the three model parameters. It is, of course, necessary to consider start-up effects when estimating the parameters in a steady-state sense.

CRADA proposals offer a means for identifying those elements of the laboratory technology base applicable to industrial use. One further step – identification of the R&D funding for those industry-applicable elements – is needed to obtain an estimate of the fraction of laboratory mission-related R&D that is transferable to industry (k).

Completed CRADAs should be a fruitful source for estimating transfer efficiency (B). Actual expenditures and accomplishments are known.

Considerable judgement will be required in evaluating the portion of resources invested in tech transfer that advance mission-related R&D (the recovery parameter, c). Aggregating assessments from individual laboratory participants in CRADAs etc. can yield a first approximation, but some validation measure, perhaps carried out by mission program managers, is likely necessary to balance the enthusiasm of transfer participants. Another consideration in determining the recovery parameter is direct payments such as royalties and industry funding into the laboratory.

With estimates of the three parameters in hand, laboratory directors can get a feel from Figure 8 as to an appropriate investment level for their particular organization and adjustments they might wish to make in their R&D activities. While low values of k (the fraction of R&D transferable to industry) may be inherent in the missions of certain labs, in general, it suggests more attention to co-planning with industry. Low values of B (transfer efficiency) may be due to inefficient work processes. Low values of c (payback to mission R&D) also suggest re-examination of the labs' tech transfer portfolio to better align with mission-related technologies.

Figure 8 shows that the maximum investment level for a positive rate of return is less than 20 percent over most of the parameter space. Higher expenditures warrant careful examination. The high values for investment occur in the region where efficiency of transfer is low ($B < 5$) and relevancy (fraction of lab R&D transferable to industry) is high ($k > 0.75$). Organizations currently operating in this region might consider measures such as adjusting CRADA portfolios or reducing tech transfer costs.

It would not be surprising to find some individual activities having a mission R&D recovery factor greater than unity ($c > 1$). However, it should be noted that if the laboratory as

a whole is operating in this range, there is an implication that mission R&D can be accomplished at a reduced level of funding. In practice, we believe this an unlikely case (and have not accounted for it in the model).

Finally, it is worth again noting the point made in Step 5 that erring toward lower investments than shown in Figures 7 and 8 carries less penalty than significant over investment. The latter sacrifices mission R&D and reduces the total amount of technology transfer while the former increases mission R&D at the expense of technology transfer.

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Appendix 1

Tech Transfer Investment Contours

J. D. Rogers

The contours shown on Figures 7 and 8 indicate the maximum recommended investment in tech transfer for a variety of model parameters. This Appendix describes the development of the investment contours based on the tech transfer model equations. The basic model equations are presented, the investment level recommendations are developed, and the contour equations are derived.

We have the technology transferred at a given investment level as

$$T(x) = kA(1-x)(1-e^{-Bx}) \quad (1)$$

where

- T = The amount of technology transferred
- k = The fraction of lab R&D applicable to industry
- A = The lab R&D budget
- B = The initial tech transfer efficiency
- x = The fraction of lab R&D budget spent on tech transfer

We wish to determine an appropriate investment level. A reasonable selection is one which ensures a positive incremental rate of return on the investment, i.e., a lab should not continue to invest in tech transfer when the incremental cost to transfer exceeds the incremental cost to develop the technology. This condition corresponds to setting the derivative of T with respect to cost equal to 1. The cost of tech transfer, including cost recovery, is given by

$$P = Ax - Acx = Ax(1-c) \quad (2)$$

where

- P = The cost of tech transfer
- c = The portion of tech transfer costs recovered

Using equations (1) and (2), we identify the derivative of T with respect to cost, P . To accomplish this, we write T in terms of P by first noting from (2) that

$$x = \frac{P}{A(1-c)} \quad (3)$$

then

$$T(P) = kA \left(1 - \frac{P}{A(1-c)} \right) \left(1 - e^{-\left[\frac{BP}{A(1-c)} \right]} \right) \quad (4)$$

The derivative is given by

$$\frac{dT}{dP} = \frac{k}{1-c} \left[-1 + \left(1 + B - \frac{PB}{A(1-c)} \right) e^{-\left[\frac{BP}{A(1-c)} \right]} \right] \quad (5)$$

Recall that

$$x = \frac{P}{A(1-c)} \quad (3)$$

then

$$\frac{dT}{dP} = \frac{k}{(1-c)} \left[-1 + (1 + B - Bx) e^{-Bx} \right] \quad (6)$$

A positive rate of return on tech transfer investment occurs when $\frac{dT}{dP} \geq 1$.

Enforcing this inequality on (6) and simplifying leads to

$$(1 + B - Bx) e^{-Bx} - \frac{(1-c)}{k} - 1 \geq 0 \quad (7)$$

which defines the conditions for a positive rate of return on investment, i.e., the maximum value of x for which the inequality holds is the maximum investment level.

An interesting special case of Eq.(7) is identifying the threshold at which any investment is indicated. This is evaluated by setting $x=0$ in (7) and results in

$$Bk + c \geq 1 \quad (8)$$

Eq.(8) can be used to evaluate the zero investment level contour. Clearly all parameters, B , k , and c have a profound impact on making an investment.

The contours shown in Figures 7 and 8 were generated using Eq.(7). A matrix of (B, k) coordinates was defined and the appropriate maximum investment level was identified. It is interesting to note that the effect of applicability (k) on investment level can be removed if all tech transfer costs are recovered ($c=1$). This does not lead to a large investment recommendation, but merely removes all dependence on k , lab R&D applicability.

Figure 1: EFFECT OF FIXED BUDGET

- The sum of dollars spent on tech transfer and mission R&D is fixed
- A dollar spent transferring technology will be unavailable for developing mission-related technology

Figure 2: EFFECT OF NON-TRANSFERABLE TECHNOLOGY

Not all of the technology developed at a Lab is transferable to industry. Some technology developed at a Lab finds no application in industry.

Figure 3: EFFECT OF TRANSFER EFFICIENCY

- Lab investment in tech transfer will, in the aggregate, follow a law of diminishing returns, that is the amount of technology transferred per dollar spent on tech transfer will decrease with increasing investment. This is because in general the Lab will transfer the high leverage technologies first. Alternately, this function can be thought of as an efficiency ranking of transfer activities underway at a given time.
- This effect is represented by the exponential function with parameter B.

Figure 4: MODELING TECH TRANSFER EFFECTS

- Combining the effects results in

$$\text{Amount of R\&D Transferred} = kA(1-x)(1-\exp(-Bx))$$

k = portion of mission R&D transferable

A = total fixed R&D budget

B = initial tech transfer leverage

x = portion of A invested in tech transfer

- Tech transfer is limited by tech transfer efficiency for initial investments and by the fixed budget constraint for larger investments
- This is a steady-state model

Figure 5: SELECTING AN INVESTMENT LEVEL

- Theoretically the Lab can operate anywhere on the x axis (i.e., with any tech transfer investment level)
- A reasonable investment strategy would be to ensure a "positive incremental rate of return" on the investment for tech transfer (e.g., invest in tech transfer until the incremental cost to transfer exceeds the incremental cost to develop the technology)
- Regions of interest in the graph
 - 1 = amount of technology transferred
 - 2 = amount of untransferred technology
 - 3 = amount of non-transferable technology
 - 4 = mission R&D not funded because of the tech transfer investment

Figure 6: EFFECTS OF TECH TRANSFER COST RECOVERY

- The "effective" cost of tech transfer can be reduced if the tech transfer investment results in mission-relevant R&D. For example, some fraction of the technologies developed in carrying out a CRADA might be mission related.
- The parameter c represents the portion of tech transfer cost recovered.
- In this case the cost to transfer technology is divided into two areas
 - 4a = the recovered cost
 - 4b = the "effective" cost of tech transfer.
- This effect will influence the maximum investment level for incremental rate of return.

Figure 7. POSITIVE INCREMENTAL RATE OF RETURN INVESTMENT LEVELS

Figure 8. SENSITIVITY OF INVESTMENT LEVELS TO COST RECOVERY FACTOR

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 MS0841 D. J. McCloskey, 1500
 MS0336 R. J. Eagan, 1700
 MS0337 A. D. Romig, 1800
 MS9003 D. L. Crawford, 1900
 MS0513 H. W. Schmitt, 2000
 MS0322 P. J. Eicker, 2100
 MS1070 R. E. Bair, 2200
 MS0509 R. D. Andreas, 2300
 MS0960 J. Q. Searcy, 2400
 MS0511 G. N. Beeler, 2500
 MS0985 J. H. Stichman, 2600
 MS0507 R. A. David, 2700
 MS0630 J. F. Jones, 2800
 MS0953 W. E. Alzheimer, 2900

MS0149 C. P. Robinson, 4000
 MS0455 G. R. Otey, 4100 (15)
 MS0421 W. C. Hines, 4101
 MS0415 C. B. Layne, 4102
 MS0415 G. S. Brown, 4111
 MS0419 C. C. Carson, 4112 (10)
 MS0419 T. M. Bomber, 4112 (10)
 MS0419 J. D. Rogers, 4112 (10)
 MS0417 W. H. Ling, 4113
 MS0423 J. W. Keizur, 4114
 MS0425 R. R. Preston, 4115
 MS1380 W. D. Siemens, 4200
 MS1380 O. D. Thompson, 4201
 MS1380 C. A. Lombana, 4211
 MS1380 J. K. S. Walter, 4212
 MS1380 K. Murphy, 4221
 MS1380 D. W. Larson, 4231
 MS1380 J. Otts, 4232
 MS0131 J. A. Weiss, 4500
 MS0159 J. R. Bode, 4520
 MS0131 T. M. Palmieri, 4503
 MS0127 B. C. Dale, 4511
 MS0127 P. E. Shoemaker, 4514
 MS1368 J. P. VanDevender, 4700
 MS1151 M. Berman, 4701
 MS0463 R. L. Hagengruber, 5000
 MS0465 J. L. Meinhardt, 5002
 MS0465 J. F. Ney, 5003
 MS0467 J. L. Wirth, 5090
 MS0429 W. C. Nickell, 5100
 MS0469 E. E. Ives, 5200
 MS9006 D. J. Havlik, 5204
 MS0459 T. S. Edrington, 5205
 MS9005 J. B. Wright, 5300
 MS0473 H. J. Saxton, 5400
 MS0558 J. B. Woodard, 5402
 MS0560 D. F. McVey, 5408
 MS0461 C. A. Yarnall, 5500
 MS0467 D. B. Hayes, 5600
 MS0458 J. R. Asay, 5602
 MS0458 L. R. Gilliom, 5603
 MS0455 P. F. Chavez, 5604
 MS9405 D. L. Lindner, 5605
 MS0769 D. S. Miyoshi, 5800

MS0768 R. W. Moya, 5804
 MS0768 J. W. Kane, 5806
 MS0570 C. W. Childers, 5900
 MS0724 D. L. Hartley, 6000
 MS0701 R. W. Lynch, 6100
 MS0735 D. E. Arvizu, 6200
 MS1337 D. E. Ellis, 6300
 MS0736 N. R. Ortiz, 6400
 MS1143 J. K. Rice, 6500
 MS0726 J. B. Woodard, 6600
 MS1395 P. E. Brewer, 6700
 MS0725 T. O. Hunter, 6900
 MS0729 D. J. Allen, 6901
 MS0722 D. Engi, 6904
 MS1067 M. L. Jones, 7000
 MS0849 E. D. Graham, 7800
 MS9001 J. C. Crawford, 8000
 MS9408 R. E. Stoltz, 8008
 MS9016 D. E. Koker, 8009
 MS9004 M. E. John, 8100
 MS9213 R. Rinne, 8104
 MS9201 R. M. Wheeler, 8112
 MS9201 R. J. Gallagher, 8114
 MS9037 R. J. Detry, 8200
 MS0954 W. J. McLean, 8300
 MS9163 W. Bauer, 8302
 MS9105 L. A. Hiles, 8400
 MS9401 R. C. Wayne, 8700
 MS9108 T. M. Dyer, 8800
 MS0151 G. Yonas, 9000
 MS0842 C. M. Hart, 9100
 MS0970 T. A. Sellers, 9200
 MS1165 J. E. Powell, 9300
 MS0766 J. R. Kelsey, 9600
 MS0301 D. J. Rigali, 9800
 MS0163 S. G. Varnado, 9900
 MS0163 D. M. Rondeau, 9903
 MS0157 J. Polito, 9911
 MS0163 P. C. Montoya, 9912
 MS0112 P. M. Stanford, 10000
 MS0109 G. A. Riser, 10000D
 MS0801 M. J. Murphy, 10300
 MS0117 R. L. Shepardson, 10400
 MS0109 M. D. Ebben, 10600

MS0161 K. C. Olsen, 11500
 MS0103 V. L. Dugan, 12100
 MS0131 D. E. Robertson, 12110
 MS0177 D. G. Schueler, 12140
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 MS1375 L. D. Bertholf, 12400
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 MS1369 C. M. Tapp, 12900
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