Appendix F
FINANCING CONSIDERATIONS AND FEDERAL BUDGET IMPACTS

With respect to the conceptual objectives proposed for discussion in chapter 6 of this report, it is important to ask not only the question of "what would their attainment cost?," but the next most important questions as well: "who would pay these costs?" and "under what circumstances?" This appendix addresses these questions, and then turns to an examination of how novel answers thereto could affect the Federal space budget.

Financing Considerations

International Considerations

Note that what is being discussed here are not NASA[1] goals and objectives, but national goals and objectives and, at least for the most part, goals and objectives for the benefit of all mankind. Therefore, for instance, when other countries can reasonably be expected to have an active interest in cooperating with the United States as parties in multinational activities, this also should be taken into explicit consideration when considering their cost to us.

John Logsdon has recently observed that: "There is now the possibility of a global division of labor and cost in space science [and exploration] . . ."[2] Officials of the European Space Agency (ESA), for instance, are reported to be of the view that ESA: " . . . anticipates contributing . . . perhaps up to 30 percent of the estimated cost [of any] space station . . ."[3] And OTA has been told, informally, by a well-informed foreign official that, if Japan and Canada also were to be included in a full partnership arrangement, "in the limit" this fraction could be appreciably larger. And recently fractions of 35 to 40 percent overall have been publicized.[4] (This 35 to 40 percent, i.e., some $3 billion [1984$] apparently is now seen by NASA as in addition to the $8 billion [1 984$] now estimated by NASA as the cost of the IOC infrastructure to the United States.)

Simply for purposes of illustration, an assumption of one-third foreign government cost-sharing is taken here as a reasonable expectation regarding at least objectives (1), (2), (3), and (4). A further assumption is made: that the U.S. Government will view its civilian space leadership role as one of orchestrating the interests, abilities, and activities of any and all of those countries **of the world** who wish to participate in space research, exploration and development, and that it will play this role in the vigorous, sensitive and innovative fashion that competitive space circumstances and the high political and financial stakes require.

Indeed, if the United States does not lead the world in this fashion, there is growing indication that, perhaps sooner than we imagine (especially with the successful Spacelab experience behind them), several European countries themselves would be prepared to "go it alone." And the U. S. S. R., as well, may be beginning to exhibit an "outreach" toward cooperation with countries outside of the Communist bloc.

The Solar System Exploration Committee of NASA's senior Advisory Committee has taken specific and positive recognition of this opportunity in its recent report: ***Planetary Exploration through Year 2000.***[5] Under the general heading of "International Cooperation, " the Committee observes that: "In the 1960s and 1970s, planetary science was clearly dominated by the United States, with major contributions by the U.S.S.R. The trend in recent years has been an increase, relative to the United States and the U. S. S. R,, in the capability and interest of other nations to participate in planetary science and exploration missions. This increasing interest has occurred against a backdrop of budgetary constraints in all nations, together with increasing sophistication and cost of planetary missions. Combined, these factors suggest that more planetary science can be accomplished in a given period if interested nations coordinate their planning and, occasionally, undertake joint missions."

But no allowance is made in the NASA budget projections–projections that average some $400 million/ year (1 983$) throughout the rest of this century[6]–for the important financial contributions that other countries could be expected to make to space science and exploration programs.

One very long-term, very successful example of multinational cooperation in the space field was developed under the enlightened leadership, and with the important assistance of, the United States: **the** Inter-

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[1] Other Government agencies, primarily the National Oceanic and Atmospheric Administration (NOAA), have Important space interests and responsibilities as well.
[2] *Science,* Jan. 6, 1984, p. 11 et. seq.; see esp. p. 13.
[3] *Science,* Dec. 9, 1983, pp. 1099-1100.
[4] *Nature,* Mar. 15, 1984, p. 216.
[5] 1983, see esp. pp. 25-26.
[6] See NASA's report, p. 27.

national Telecommunications Satellite Organization (I NTELSAT). Some 20 years ago, the only countries involved in civilian satellite communications were the United States, the United Kingdom, and France. Today, INTELSAT counts 109 countries as members; the countries conduct a useful, profitable, and rapidly growing space-related business–long-haul trunk communications—which grossed some $400 million in 1983, and in which the required U.S. investment share is now down to less than 25 percent. (The business is now so profitable that, last year, potential competitors came forward.) And INTELSAT has been joined by INMARSAT in the maritime communications area; INMARSAT counts even the U.S.S.R. among its members.[7]

Finally, the President has taken steps to see that the matter of international cooperation—indeed, perhaps international collaboration—in the civilian space area will receive direct and important attention by the executive branch. In his radio address during the week of his 1984 State of the Union message, the President observed that: "international cooperation . . . has long been a guiding principle of the United States space program [and that] just as our friends were asked to join us in the Shuttle program, our friends and allies will be invited to join with us in the space station project." In response to this Presidential directive, **NASA's Administrator has recently visited several other** countries to explore the matter of their working on any "space station" program with the United States.

Private-Sector Considerations

Also, when our private sector can reasonably be expected to assume the cost (in anticipation of commercial-industrial sales and profits), or at least an important fraction thereof, this should be taken into consideration. This should be the case for at least objectives ***(2), (5), (6), (7),*** and (10) (see ch. 6).

For much of 1983, and still continuing, NASA has had a task force studying what it might do to speed and enlarge the "commercialization" of space. And the Department of Transportation (DOT) has recently been charged by the President with assisting an expendable launch services industry.

Now the President has given a powerful general thrust to the matter of much greater economic participation by our private sector in space-related activities, In his **1984 State of the Union address he expressed himself of the judgment that: " . . . space holds enormous promise for commerce today," and was** quite specific in justifying his decision to start work on the development of space infrastructure in terms of its eventually allowing for " . . . living and working in space for . . . economic . . . gains. " In his later radio address he stated that he expects: " . . . a space station will open up new opportunities for expanding human commerce . . . ."

The legislative branch too, perhaps smarting because of the seemingly endless Landsat commercialization difficulties, and responding to the continuing hesitancy within NASA concerning their space applications responsibilities, has moved to strengthen the law quite specifically regarding "space commercialization." NASA'S fiscal year 1985 authorization bill, which became Public Law 98-361 with the President's signature on July 16, 1984, makes a basic change in the "National Aeronautics and Space Act of 1958." It amends section 102 of the act by including a new paragraph (c) as follows: "The Congress declares that the general welfare of the United States requires that [NASA] seek and encourage, to the maximum extent possible, the fullest commercial use of space." This is strong, unambiguous and "revolutionary" language for our publicly funded civilian space program's "char ter."

It would seem reasonable, therefore, to imagine that the kind of private sector participation suggested here in addressing certain of the 10 conceptual objectives will, in fact, be realized.

International Plus Private-Sector Cost Sharing Considerations

Thus, when the financial support of both other countries and our own private sector are taken into consideration, the ***net*** U.S. public cost of meeting these 10 conceptual objectives is estimated to be some $25 billion to $40 billion (1984$), i.e., some 70 percent of their estimated $40 billion to $60 billion total cost.[8] (See table F-l). The average net public cost for the first 5 years considered here would be some $2.0 billion/year (1984$); during the last 5 of the 25 years the average net public cost could decrease to about one-half this rate. (See table F-2.)

These expenditure rates suggest that, with the completion of the initial modest Moon settlement, the projected NASA budget could allow a major program of human exploration of Mars (and of one or more asteroids) to begin in earnest.

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[7] **For a thorough discussion of the satellite communications area, see the OTA report *International Cooperation and Competition in Civilian Space Activities* (now in press).**

[8] **Norman R. Augustine, "The Aerospace Professional . . . and High-Tech Management," *Aerospace America,* March 1984,**

Table F-l .—USA Net Public Cost (billions of 1984 dollars)

	Total cost	Other countries	Private sector	USA net public cost
1. Establish a global information system/service regarding natural hazards	2	0.7	0	1
2. Establish lower cost reusable transportation service with the Moon, and establish human presence there	20	7	1	13
3. Use space probes to obtain information regarding Mars and some asteroids prior to early human exploration	2	0.3	0	2
4. Conduct medical research of direct interest to the general public	6	2	0	4
5. Bring at least hundreds of the general public into space for short visits	0.5	0	0.4	0.1
6. Establish a global, direct, audio broadcasting, common-user system/service	2	0	2	0.2
7. Make essentially all data generated by civilian satellites and spacecraft directly available to the general public	0	0	0	0
8. Exploit radio/optical free-space electromagnetic propagation for long distance energy distribution	0.5	0	0	0.5
9. Reduce the unit cost of space transportation and space activities	5	0	0	5
10. Increase space-related private sales[a]	0.5	0	0.5	0
Total	= 40[b]	=10	=4	= 26[c]

[a]This would advance the prospects of successfully a& dressing all goals and all other objectives.
[b]The actual total cost including a 50-percent increase could be $60 billion; the same increase could affect all other cost estimates.
[c]With a 50-percent cost increase, this cost could be $40 billion.

NOTE: Some rows do not sum due to rounding.

Table F-2.—First Rough Estimate of the Total Cost/Year and the Net Public Cost/Year (in billions, 1984 dollars) for the First 5 Years, of Attaining the 10 Conceptual Objectives

	Total cost (and the years) to attain each "objective	Total cost/year, first 5 years	Net public cost (and the years) to attain each objective	Net public cost/year, first 5 years
1.	2 (lo)	0.20	1 (lo)	0.10
2.	20 (15)	1.33	13 (15)	0.87
3.	2 (15)	0.13	2 (15)	0.13
4.	6 (5)	0.40	4 (5)	0.28
	0.5 (5)	0.10	0.1 (5)	0.02
6	2 (lo)	0.20	0.2 (lo)	0.02
7.	0 (25)	0.00	0.0 (25)	0.00
8.	0.5 (lo)	0.05	0.5 (lo)	0.05
9.	5 (15)	0.33	5 (15)	0.33
10.	0.5 (25)	0.02	0 (25)	0.00
	=40	= 3	=26	==2

Economic-Growth Considerations

PROJECTED GROWTH IN PRIVATE SECTOR SALES AND RELATED TAX REVENUES

Beyond the cost-offsetting financial participation of other cooperating countries and our own private sector, it is important to obtain some useful sense of the present, and future, marginal net cost to the U.S. general public of its civilian space activities—i e., setting aside further consideration of the over $200 billion (1984 adjusted) "sunk cost" of our investments in the civilian space area to date, and considering only expenditures from now on.

To date, except for the satellite communications area, the United States' publicly supported civilian space program has been essentially one of basic research, exploration, and development of technology required to support both. Economic returns have been expected to result from general "spin off" to the private sector from these otherwise-directed R&D activities. The general sense is that to some important extent that has apparently happened, even though the

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evidence on the macroeconomic level is admittedly difficult to come by.

Let us start, therefore, probably conservatively but objectively and reasonably quantitatively, by noting that the present (1 983 year-end) U.S. commercial-industrial space-related annual sales of capital equipment (essentially all in the satellite communications business, for satellites, their launching, and their associated ground equipments) are some $1.6 billion/ years If satellite insurance sales, operations and maintenance (O&M) charges related to surface equipments, end-to-end circuit lease charges and lease charges for in-space microwave transponders (there are now some ***400*** in orbit which are owned by U.S. companies) are added, total U.S. private-sector space-related sales are now probably $2 billion to $3 billion per year.

This sales figure, at least in the satellite communications long-haul circuit leasing area where records have been kept since the outset of private sector operations (see INTELSAT's annual reports) is a consequence of an average annual growth rate of some 15 percent/year, compounded, for nearly the past 20 years.[10]

If it is assumed that the total of all Federal, State, and local tax rates on these sales averages 20 to 30 percent,[11] then, roughly, $0. 5 billion/year in Government tax revenues are now being derived from these sales. Thus, while the gross civilian space-related Government expenditures are some $7 billion/year today, in fact the net Government expenditures could be considered to be significantly less—i.e,, effectively some $6.5 billion/year (or some 7 percent) less.

Now, assume for the purpose of illustration that the total sales generated in the satellite communications area, enlarged in time by space-related navigation, position fixing, remote sensing, materials processing, tourism, private launch and transportation services, space platform leasing, etc., continues to grow at the current rate, i.e., some 15 percent/year, compounded–a doubling about every 5 years. The projection for this rate of growth has been made by NASA and others and may prove to be conservative. The most recent projection, by Jerry Grey[12] is that: "Satellite communications demand is still growing rapidly at between 20 and 30 percent per year and is projected to continue at this rate to the end of the century, despite potential inroads by optical fibre cables. projections for turn-of-the-century annual volume (spacecraft, launch and integration services, and communications services themselves) range from $30 billion to$100 billion." A 15 percent/year, compounded, sales growth throughout 1984-2000 on a 1983 base of $2 billion would produce sales of some $20 billion in 2000; on a $3 billion base, some $3o billion.

Of course, the rate of 15 percent/year, compounded, may prove to be optimistic. **If, instead, a 10 percent figure is used, the year 2000 sales projection would exceed $10 billion on a present $2 billion base, and $15 billion on a present $3 billion base.**

Further, assume either that Government civilian space-related expenditures remain at about $7.o billion (1983) per year or that they grow, in real terms, at 1 percent per year, compounded, as is NASA's desire and this administration's expressed intention.

(No attention is given here as yet to the reimbursements made to the Government for the provision of space-related Government services—now almost wholly the reimbursement for the provision of Shuttle flights.)

Under such circumstances and with such assumptions, over time, the effective net Government cost of supporting the civilian space program (in billions of 1983 dollars) could be considered as decreasing rapidly. (See tables F-3 and F-4.)

Under either assumption regarding future NASA appropriations, and a projected 15 percent/year tax revenue increase, the "break-even" point would be reached in some 20 years; i.e., in one generation the effective net public investment required to underwrite our entire Government civilian space program—either a program of today's magnitude or, by then, some 20 percent larger–would be reduced to zero. Even with the lower 10 percent/year tax revenue growth projection, the effective net public cost would then be a great deal less than today's. And, over the next 20 years, a total of tens of billions of dollars (1 984) in tax revenues would have been generated.

This is such an important observation and prospect that it bears further elaboration. For the prospect that such extraordinary private-sector space-related sales and tax revenue projections might well be attained suggests that the Government could commit itself to promoting, vigorously and innovatively, the growth

[9]This figure was provided to OTA by Janet Martinusen ot the Aerospace Industries Association of America, Inc.)

[10]In what follows, note that no attention is given either to the influence of inflation or to any decrease in nonspace-related sales as a consequence of the growth of space-related sales; i.e., this discussion must be considered—particularly by economists–as illustrative and qualitative, not methodologically exhaustive and quantitative.

[11]*Economic* RepOr-f *of the President,* transmitted to the Congress, February 1984 (Washington, DC: U.S. Government Printing Office, 1984); *Study of 1982 Effective Tax Rates of Selected Large U.S. Corporations,* prepared by the staff of the Joint Committee on Taxation (Washington, DC: U.S. Government Printing Office, November 1983).

!Z"Investing In Space . . . ," *Aerospace America,* April 1984, p. 90.

Table F-3.—Growth in Tax Revenues From Private Sector Space. Related Sales, and Their Influence on the Net Cost of the Federal Civilian Space Program (billions of 1983 dollars per year–assuming a 15°/0 sales growth rate)

		Government space expenditure net cost	
Years	Tax revenues growth @ 150A/year	A constant $7 billion/ year (1983)	$7 billion (1983) increasing at 1'\Olyear
O (1983)	0.5	6.5	6.5
5 (1988)	1,0	6.0	6.4
10 (1993)	2.0	5.0	5.7
15 (1998)	4.1		4.0
20 (2003)	8.2	(1.2)	0.3
25 (2008)	16.0	(9.5)	(7.5)

Table F-4.—Growth in Tax Revenues From Private Sector Space-Related Sales, and Their Influence on the Net Cost of the Government Civilian Space Program (billions of 1983 dollars per year–assuming a 10% sales growth rate)

		Government space expenditure net cost	
Years	Tax revenues growth @ 10%/year	A constant $7 billion/ year (1983)	$7 billion (1983) increasing at 1'/Olyear
O (1983)	0.5	6.5	6.5
5 (1988)	0.8	6.2	6.5
10 (1993)	1.3	5.7	6.4
15(1 998)	2.1	4.9	6.0
20 (2003)	3.4	3.6	5.1
25 (2008)	5.4	1.6	3.6

of commercial and industrial space-related sales. That is, the Federal Government, working in close concert with the private sector, would work to see, over time, a great increase in such high-technology sales, thereby generating proportionally much greater tax revenues which could be looked upon as "offsets" to the public R&D expenditures on space. Also, if successful, such an initiative would result in an effective transfer of much of the responsibility for the health and growth of space-related economic activities from the public to the private sector.

The President has just taken particular note of this possibility: the July 20, 1984, White House "Fact Sheet" entitled "National Policy on the Commercial Use of Space" states that "In partnership with industry and academia, Government will expand basic research and development which may have implications for investors aiming to develop commercial space products and services."

Of course, private-sector gross revenues also can be expected to support space-related commercial-industrial R&D. Again, assuming that sales grow at the average annual rate of 10 to 15 percent, compounded, and assuming as well that about 5 percent of these sales is spent by the private sector on space-related R&D (probably a conservative assumption; C. Paul Christensen recently observed that: " . . . a successful high-technology company normally must spend 5 to 10 percent of its gross sales on R&D''[13]) then, 20 years from now, a private-sector R&D investment rate of some $1 billion to $2 billion (1 984) per year would have been reached.

The total Government investment (again, assuming that NASA appropriations increase at 1 percent "real growth" per year, compounded) plus the commercial-industrial investment in space-related R&D would be expected to increase substantially overtime. (See table F-5, which assumes a 15 percent projected growth rate for the private sector.) By the end of the next quarter of a century, the country's overall space-related R&D activities could reach a level that would be nearly twice the size of today's Government program and that, by then, would be increasing at some 5 percent/year, compounded.

These are extraordinary projections, and they could well turn out to be conservative ones.

To put such numbers into a space R&D and exploration perspective, note that a U.S. public expenditure of an average of some $1 billion/year over, say, 15

[13] *Science,* Apr. 13, 1984, P. 117

Table F-5.—Growth in Yeariy U.S. Space investment, Federal (increasing at 1°/0 annually) Pius Private (increasing at 150/0 annually)

	Investment (billions of 1983 dollars per Year)		
Years	Government	Private	Total
O (1983)	7.0	0.1	7.1
5 (1988)	7.4	0.3	7.7
10 (1993)	7.7	0.5	8.2
15 (1998)	8.1	1.0	9.1
20 (2003)	8.5	2.0	11.0
25 i2008)	9.0	4.1	13.0

to 20 years could allow us, along with other cooperating countries, to place a modest settlement on the Moon. In similar fashion, an additional some $2 billion/year, over 20 to 30 years, could allow a first human landing on the planet Mars. And each of these sums would include paying for that kind and amount of LEO infrastructure specifically required to assure the efficient operational conduct of these ventures,

HISTORICAL BASES FOR A PROJECTION OF SALES GROWTH IN THE PRIVATE SECTOR

While, of course, no brief can be held with complete confidence, either **for the absolute rates** of increase of space-related sales, or for such a long-term continuation thereof as is outlined here—and other countries have also already clearly perceived the great longer-term economic prospects in the space area[14]–it must be remembered that the U.S. investment in the publicly supported civilian space area has provided an enormous base of assets, understanding and experience for so doing; that the active interest of our private commercial-industrial sector in investing in space assets and activities, already non-trivial, is quickening; and that we have other high-technology growth "stories" as useful references: air transportation, computers, radio, television, medical technology, communications, etc.

For instance, President Karl G, Harr of the Aerospace Industries Association observed, in his report of December 1983, that " . . . there has been a considerable acceleration in the building of commercial communications satellites . , . that's just the beginning of an indicated boom; worldwide projections show enormous increases in demand for satellite communications services between now and the end of the century." And Secretary of Transportation Elizabeth Dole is recently quoted as saying, with reference to that Department's new responsibilities for the commercialization of expendable launch vehicles: " . . . this involves 'a whole new industry' with growth prospects estimated at up to $10 billion over the next decade. "[15]

A recently published OTA report, *International Competition in Electronics,* **notes that: "Sales of the more than 6,000 electronics manufacturers in the United States exceeded $125 billion in 1982 and are growing rapidly . . . the growth rate over the past decade reached nearly 15 percent [per year, compounded]."**[16-17]

As one general example: ***Forbes*** magazine has recently[18] surveyed the sales growth of 25 leading companies in the electronics area, comparing the average of such sales for the most recent 5 years with the average of the preceding 5 years. The annual sales growth of the top one-half of the companies averaged 23 percent, compounded.

The early days of commercial radio provide another example of how the growth rate of a newly introduced service supported by new technology can attain phenomenal values. "[In] the spring of 1922 . . . the sale of radio sets, parts, and accessories amounted to more than $60 million annually. By the **end** of 1929, sales had climbed to a remarkable $843 million."[19] This is an annual **growth rate of greater than** 40 percent/year, compounded. More recently, lasers and their applications have become at least as **big a high-technology business as has satellite communications, "In the past 2 decades . . . the market for laser-related systems that solve practical problems has grown to over $3 billion per year , . . "**[20]

As an individual company example, over the past 7 years the International Business Machines Corp. (IBM) has seen its sales grow at an average annual rate of 14 percent, compounded, and its top financial officer was quoted late last year as venturing the prediction that " . . . sales growth in the next several years will surpass the 14 percent rate . . . ";[21] in fact, sales grew 17 percent in 1983.[22] Seven years ago IBM's sales

[14]See th.OTA report on *International Cooperation and Competition in Civilian Space Activities, 1984.*

[15]*Aerospace Daily,* Jan. 19, 1984, pp. 97-98.

[16]November 1983, p. 108.

[17]N.B. Neither this figure, nor any that follow which reference sales growth in either absolute numbers or annual rates, have been adjusted to reflect the unusually high inflation rates that held during the late 1970s and early 1980s. Consequently, they are inherently "optimistic" if taken as an augury of future sales growth. But, at the same time, this was an epoch during which business expansion was abnormally repressed by the same inflationary pressures—pressures that, one hopes, will not soon be repeated.

[18]Jan. 2, 1984, p. 176.

[19]Steven L. Del Sesto, "Technology and Social Change, " in *Technological Forecasting and Social Change,* vol. 24, pp. 183-196; see esp. p. 183.

[20]*Science,* Apr. 13, 1984, P. 117.

[21]*Wall Street Journal,* Dec. 9, 1983, p. 5.

[22]*Wall Street Journal,* Dec. 19, 1984, p. 2.

were some $15 billion; today they **are some** $40 billion, and 3 years from now could approximate $55 billion. It is clear that the absolute size of sales is not necessarily **an** impediment to further sales growth when desired new assets and services are being introduced and adopted—not even at the $30 billion to $50 billion/year **level.**

Other, more recent, high-technology commercial-industrial examples abound. Over approximately the past decade (ending in 1982) the average annual compound growth rate in sales (taken from Moody's or individual company reports) for the Communications Satellite Cooperation was 15 percent; for INTELSAT and Texas Instruments: 16 percent; for Hewlett-Packard: 23 percent; and for MCI: 68 percent.

Thus, it does seem reasonable to expect that, with energetic and innovative consideration explicitly given to cooperative Government-private sector promotion of United States commercial-industrial space investments and initiatives—initiatives directed both to opening up new uses related to space and to reducing the unit cost of producing space assets and conducting space operations–the next quarter of a century could see truly important, perhaps outstanding, **growth in** our civilian space-related sales, with all that this should imply for employment, tax revenues, international trade, etc. As the earlier referenced OTA report succinctly states: " . . . the United States needs to search for new engines of growth to drive the economy into the 21st century . . . "[23] and " . . . special stress should be laid on . . . R&D and technology plus measures aimed at stimulating investment in new and innovative firms . . . "[24] And, as a recent ***Washington Post*** **article emphasized: "America's strength** in exporting is not in standardized, commodity products, but in high-technology specialized products that draw on the huge pool of American know-how and expertise;] specialized, higher technology products . . . are America's bread and butter."[25-26]

LEGAL AND EXPERIENTIAL BASES FOR FEDERAL/PRIVATE-SECTOR COOPERATION IN ECONOMICALLY DIRECTED R&D

It is important to note that there is some precedent in Federal law for exploring Government-private sector initiatives in stimulating sales in a high-technology domain such as **space.** The "Stevenson-Wydler Technology Innovation Act of 1980"27 states: "(a) Policy. It is the continuing responsibility of the Federal Government to ensure the full use of the result of the Nation's Federal investment in research and development. To this end, the Federal Government shall strive . . . to transfer federally . . . originated technology . . . to the private sector. " Also, for instance, the Department of Defense (DOD), using the 1982 authority incorporated into formal law **by** inclusion of appropriate language in Title 10 of the United States Code, Section 22394, employs very long-term contracting for utility services in its "Venture Capital Energy Procurement Program by the Military Services. "[28] DOD uses this program to excite the private sector to develop and use new technology to provide DOD with energy services at lower cost than otherwise; this approach is now being replicated by certain States and municipalities.

And the features of the "Small Business Innovation Development Act of 1982,"[29] which was enacted to (among other things) " . . . utilize Federal research and development as a base for technological innovation [so as] to contribute to the growth and strength of the Nation's economy, " also could be utilized by NASA, NOAA, DOT and other space-related executive branch offices. This act requires that as much as 1 1/4 percent of the "annual extramural" R&D appropriations of most major Federal agencies be spent with smaller and, presumably, more aggressive, more entrepreneurial, business organizations.

Perhaps, say, a small fraction of 1 percent of the total annual NASA and Commerce/NOAA/DOT appropriations could be spent directly and specifically to prompt activities that offer reasonable promise of furthering the growth of space-related sales in our private sector. In close concert with our private space-related business sector, the Government, in order to realize a more effective linkage of its R&D to the private marketplace, could use these funds to help "focus" the scientific, exploration, and technological results of the other 99.5 percent on the task of increasing business sales.

Such a requirement would be somewhat analogous to that holding for the nine national laboratories that operate under the aegis of the Department of Energy. Under the terms of the Stevenson-Wydler Act (sec. 11 (b)) these laboratories are obligated to spend not less than 1/2 percent of their funds on activities that

[23] *International Competition in Electronics,* p. 466.
[24] Ibid., p. 502.
[25] Jan. 8, 1984, p. G 1/G8.
26 Notably, in the private commercial-industrial world, the space area is not yet even considered to be important in terms of "high technology"—see *U.S. News and World Report,* Jan. 16, 1984, p. 38 where, in defining "High Technology: What Is It?," space assets and activities go unmentioned.

[27] Public Law 96-480, Sec. 11. Utilization of Federal Technology, Oct. 21, 1980.
[28] See an article by this title in the 10th Energy Technology Conference Report, p. 230 et seq.
[29] Public Law 97-219.

would see the technology that they develop, using Federal funds, "transferred" to our private sector. The potential power of such an approach is a matter of public record. One of these laboratories, Sandia, spends more than 1 percent of its budget in this fashion, and has had a long list of successful transfers. [30] In one area alone, that of clean-room technology used by hospitals and electronics companies, Sandia estimates that sales have now reached $200-million/year by 70 companies. Much as in the case of satellite communications and NASA (but scaled down by just an order of magnitude), the total tax revenues provided by such sales, probably some $50 million, is some 8 percent of Sandia's $7oO million annual budget.

In an article entitled "The Making of a Conservative Science Policy," Wil Lepkowski observes that: . . . from 1982 onward [the present] Administration . . . drew back from its original insistence that the government had no business developing new technologies for the private sector. " He suggests that: **"In fact, there is nothing** wrong with the government's developing ideas, concepts, and hardware for the private sector to exploit for the good of the public." And he concludes: "What the administration will notice in 1984, and try to stimulate, is evidence from research agencies that their programs are contributing to the economy, innovation, and productivity. We can expect to see growing evidence of the major contribution of the conservative revolution: closer and closer integration of economics with science and technology. After many decades, policymakers are doing a better job of bringing the two together. That, by itself, is an achievement."[31] The President's 1984 State of the Union address and his subsequent radio address both bear out Lepkowski's expectation in the civilian space area,

The Congressional Research Service recently observed that: " . . . many analysts believe that Federal policy to harmonize governmental and private sector support of private science and technology probably could be improved significantly without [an excessive] degree of government-private sector collusion . . . "[32] And it prepared a report for the use of the Committee on Commerce, Science, and Transportation of the United States Senate that notes that:[33] "With increasing [prospects] of space commercialization . . . the Government may have to provide funding if the private-sector [at the outset] is unwilling or unable to fund the R&D [and it] may be necessary to increase support for initial R&D funded by the Government if commercial activity is deemed important." The report raises serious questions as to ". . . the effectiveness of [the] mechanisms [now used by NASA] for promoting [space] commercialization," But the heretofore-mentioned example of Sandia and, for instance, the pressure for AT&T's Bell Labs, with its $2 billion/year budget, to become consumer- and market-oriented,[34] suggests that the executive branch, and especially NASA and Commerce/NOAA/DOT, if properly prompted by the President and Congress and led by imaginative, experienced, and tough-minded leaders, could make the required transition. For instance, NASA's recent request for proposals for a Shuttle marketing support contract is an important step in that direction.[35] So is Executive Order #12465 (February 24, 1984), designating the Department of Transportation as the lead agency "for encouraging and facilitating commercial ELV activities by the United States private sector."

THE SPACE-RELATED PRIVATE SECTOR GROWS UP

Slowly, the private sector is learning more about space, more about the prospects of doing business there, and more about how to deal with the Government in so doing.

For instance, NASA and the 3M Co., St. Paul, MN, signed a memorandum of understanding earlier this year that will enable the company to fly aboard the Shuttle several experiments related to the growth of organic crystals and the development of thin films. NASA has signed one major joint endeavor agreement with McDonnell Douglas and Johnson & Johnson for the production of pharmaceuticals in space, and currently is in discussions with approximately 20 companies contemplating future space endeavors.

Other firms have been involved in discussing a wide range of experimental activities such as electroplating enhancement, improvement in catalytic materials, formation of glass alloys, research in long-term blood storage, development of remote-sensing techniques, development of smaller space vehicles and components of a "space station," etc. The firms include: Fairchild, Micro-Gravity Research Associates, John Deere, Space Industries Inc., DuPont, Honeywell, A.D. Little, Orbital Sciences Corp., American Science and Technology Corp., Ball Aerospace, C2Spaceline, Sparx, Spaceco Ltd., and Astrotech.

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[30] *Technology Transfer at Sandia National Laboratories: First Annual Report, SAND83-0345,* March 1983.

[31] Technology *Review,* January 1984, p. 39 et seq.

[32] See the *CRS Review,* January 1984, p. 14.

[33] Congressional Research Service, "Policy and Legal Issues Involved in the Commercialization of Space" published as a Committee Print (No. 98-102), Sept. 23, 1983, pp. 17-18.

[34] See */formation Technology Research and Development, OTA,* in Press.

[35] NASA Industry Briefing for STS Marketing, May 1, 1984.

Of greatest importance in considering the matter of the Government's working to promote growing private-sector sales in the civilian space-related area are, of course, the views and policies of the leaders of both the legislative branch and the executive branch, particularly the President himself. President Reagan has made his views and desires clearly known. In his radio address of January *28,* 1984, he stated: "We expect space-related investments to grow quickly in future years . . . .NASA, along with other departments and agencies, will . . . promote private investment . . . we're going to bring into play . . . the vitality of our free enterprise system. "

So, whatever views the administration has in regard to close cooperation between the Government and the U.S. private sector in general, and however much attention such cooperation receives in other areas, it is now clearly, indeed forcefully, on record as supporting it between civilian space-related offices such as NASA and the commercial-industrial-financial institutions that can be expected to profit from such cooperation. To repeat: " . . . NASA . . . will promote private investment , . . ,"

And, of course, to the extent that the private sector provides space assets and operational services that technology, the marketplace, and its growing free-enterprise capabilities allow, and conducts RDT&E activities at the multibillion-dollar/year level, NASA would be able to concentrate on the more basic research, the more demanding space exploration, and the more exotic "cutting edge" technology required to support both.[36] First hints of the potential of such a private sector move are beginning to appear: Rockwell International is studying the commercial construction, launch, and maintenance of a private-sector in-orbit "electric utility, " costing more than a billion dollars, that would be prepared to offer electrical power as a service to a host of space operations; J' Space Industries is readying itself to develop, produce, and deploy a sophisticated space platform by 1988; the Astrotech Corp. is holding discussions about their purchasing a Shuttle Orbiter at a price of some $2 billion (1984); etc.

Impacts on the Federal (NASA) Space Budget

What can be concluded from simply studying and projecting the Federal civilian space program budget itself?

[36]See the article by George Mueller in *Aerospace America*, January 1984, p. 84 et seq.

[37]See the International Section of *Renewable Energy News*, December 1983.

As an initial reference point, the NASA fiscal year 1984 budget authorized by Congress is adopted. It is usually presented in the general form of table F-6. (The data source is the Congressional Record. In all that follows, rounding can influence the last figure in sums. All other Government ***civilian*** space expenditures are small relative to NASA's, and their inclusion would unnecessarily complicate this discussion.) Inasmuch as only the space R&D elements of this budget are of concern here, this table presents just these.

Table F-6 shows that $2 billion will be spent on Shuttle production (Space Transportation Capabilities Development) in fiscal year 1984. The Shuttle production and development program is nearly complete; when it ends, there will be about $2 billion that is unspoken for in the NASA budget, if current funding levels continue.

Two other financial matters must be taken into consideration: the reimbursement to the Government for Shuttle transportation services when the Shuttle is used by the private sector and other countries; and the 1 percent/year real growth in funds that would be made available to NASA if the present administration's expressed budget views in this regard for future fiscal years are accepted by Congress and continue indefinitely.

That the payments for use of Shuttle launch services are already reimbursing the Government for 4 percent of the publicly funded civilian space program, and that these payments are now expected to grow to truly important dimensions soon (perhaps 14 percent by 1989), should be appreciated by all with a serious interest in the cost of this program. The NASA Ad-

Table F-6.—NASA Overall Authorization for Fiscal Year 1984 (billions of dollars)

A. R&D.	5.88
B. Construction and facilities	0.13
C. Program management	1.24
D. Total	=$7.30
The R&D element (A, above) consists of external contract funds for:	
1. Space transportation capabilities development	2.01
2. Space transportation operations	1.55
3. Physics and astronomy	0.56
4. Planetary exploration	0.22
5. Life sciences.	0.06
6. Space applications	0.31
7. Technology utilization	0.01
8. Aeronautical research and technology	0.32
9. Space research and technology.	0.14
10. Tracking and data acquisition	0.70
	=$5.90

ministrator has reported at a press briefing[36] that the reimbursements—primarily for **Shuttle flight services—approached $300 million in fiscal year 1984, and that he expects that they will approximate some $7oo million in fiscal** year 1985. Further, he stated that: "1 still anticipate reaching the break-even point in 1988 or 1989. "

Thus (even without considering the cost-offsetting importance of tax revenues generated by private-sector space business) the net cost to the public of our publicly funded civilian space program even now is significantly less than the gross cost because of this Shuttle cost reimbursement: it is $6.6 billion net out of $6.9 billion gross. Next year the expected reimbursement income would more than offset a 4 percent inflation rate. (Considering the tax revenues as an additional effective "offset" would reduce the $6.6 billion to $6.1 billion. That is, the net cost could be considered to be some 11 percent less than the gross cost, and falling.)

And, finally, NASA now has some reason to expect that funds for its program would increase by 1 percent/year plus any inflationary increase. If inflation compensation plus 1 percent real growth becomes emplaced in NASA's annual appropriations, it would have important influence on the pace at which space-related objectives, such as those suggested here, could be pursued. A 1 percent "real growth" on a base of $7 billion/year would provide a total addition of some $10 billion by the end of this century, and a total approaching $25 billion in the next 25 years—i.e., an average of some $1 billion per year (1984$) over this latter interval.

Under the assumptions made here, three conclusions may be reached concerning cost and financing considerations:

1. In the absence of any private-sector or other-country financial participation-i .e., under circumstances whereby the full cost of addressing the ten conceptual objectives would be defrayed by U.S. public funds, and assuming that the funds continuing to become available year-to-year would be in the same amount as those now available under NASA's "budget envelope," then, starting 2-3 years hence, the essential completion of Shuttle-related development could provide some ***$2*** billion (1984) /year—i,e., some $50 billion (1984$) over the next quarter of a century,
2. If, to this RDT&E "wedge" is added the anticipated 1 percent/year "real growth" in appropriations, in addition to an indexing of appropriations to neutralize the influence of inflation, the next ***25*** years could see a total of some $25 billion (1984$) added to the $50 billion made available through the Shuttle RDT&E completion—i.e., a total of some $75 billion (1984$). Thus, just these two measures alone would suffice to see (from the financial viewpoint alone) that the ten conceptual objectives could be satisfactorily addressed within the next quarter of a century.
3. If the two preceding assumptions are retained, and if, in addition, the full cost were to be shared by other countries and our private sector, in the fashions and to the degrees outlined earlier, this measure (again, speaking just of financial, not political or technological circumstances) would allow the ten conceptual objectives to be attained in, say, 20 years since this would allow some $15 billion (1984$) of public funds to be used to accelerate the schedule. Alternatively, the 1 percent per year "real growth" and/or the "base" figure of $2 billion could be reduced.
4. Whether or not such public and other funds are indeed made available could be influenced, positively and importantly, by two other circumstances:
   - If the incorne from other countries and the private sector for the use of the Shuttle increases as is now hoped/expected, then, in a half-dozen years or so, this would amount to NASA appropriations being, in effect, "offset" by as much as some $2 billion (1984$) per year;
   - If our private space-related sector could be stimulated to maintain its present rate of sales growth, it could begin to make significant additional space R&D investments itself—investments that could grow to billions of dollars/year in the next two decades or so; and
   - If the tax revenues "thrown off" by our private sector's commercial-industrial sales continue to increase in the future as they have in the past, i.e., if a 10 to 15 percent per year, compounded, growth rate were to continue over the next quarter of a century, they could, at least to some extent, be looked upon also as an important "offset" to the gross public cost of our publicly supported space program, inasmuch as they would amount to scores of billions of dollars (1984$).

Clearly, under such general circumstances as these, funding limitations would not prevent the United States from undertaking an ambitious publicly supported civilian space program throughout the next quarter century.

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[36] *The Washington Post,* Feb. 6, 1984, page A-9.