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INTRODUCTION

Transferring space technology from the public sector to the private has been the hallmark of American space policy since its earliest inception. This pattern reflected early launch technology and an already existing structure for private-public cooperation as embodied in the NACA, predecessor of NASA. Dramatic changes are occurring in the space industry environment, transfer of government space technology becomes an even more critical issue. This paper briefly examines several methods by which such technology is transferred from the public sector to the private. One must note that a reverse process also occurs, private to public. Attention will be upon privatization as a transfer strategy since it is politically very attractive but we will also discuss briefly direct transfer, developmental assistance, and spinoffs (indirect technology transfer) .

CHANGING POLICY ENVIRONMENT

Since the early space age, technology transfer has been essential for developing an independent private space sector. Space technology was derived from military oriented systems for several reasons. First, national security related motivations justified the large expenditures necessary before space technology achieved success. The harshness of the flight environment and the high capital investment, flight failures being common - created an expense level unacceptable commercially given the initial paucity of demonstrated marketable products. Visions of the future do not pay the bills, bridging the gap became the goal. Evidence of that eventual success exists in the current ELV fleet where the workhorse vehicles including the Atlas, Titan, and Delta are derivatives from earlier missile programs. Newer launch technologies are coming on line but build upon the earlier flight experience. Second, government programs both military and civilian, had the capability early on to assume the risks necessary to push the envelope. Costs were not inconsequential but were defined politically in terms of national security goals compared to the constraints of making a profit to justify continuation. Remote sensing and communications satellite development, for example, benefited from that greater flexibility. This developmental system benefited a space industry still seeking markets sufficient to justify their efforts. Unfortunately, the underpinnings of that public development process have drastically altered.

In recent years, the fiscal climate has chilled noticeably for government funded space activities, both military and civilian. Conversely, the private sector building upon those earlier efforts and technologies appears, especially in remote sensing, communications, and global positioning-derived space systems, to be moving into a more positive economic environment. Those private activities, however, still benefit from technology transfer although in some instances the flow may be reversed, from private to public (i.e., NASA and DOD purchases of off the shelf space technology when appropriate) . Regardless, strong pressures press upon the public sector to proactively engage in technology transfer activities. Those activities, however, carry both benefits and costs, making assessment difficult as to which is the most useful. There is another urgency concerning technology transfer that is often implicit rather than overt. As fiscal reductions threaten the survival of various programs and agencies, there is a growing sense that a wider audience becomes necessary else the technology or the methodology be lost in the wreckage of discarded initiatives. The Clementine mission emerged from a downsized BMDO with interesting implications for space applications but clearly if downsizing had not occurred the technology would likely have remained inhouse for the exclusive benefit of its parent organization.

Transferring technology between the private and public sectors sounds simple in theory but often proves difficult to execute successfully in practice. NASA has engaged in different initiatives aimed technology transfer but even the DOD has become much more proactive as its budgets decline (Scott, May 16, 1994) . The issue is often whether the technology itself is directly transferred or is the knowledge which can be applied in commercially relevant contexts what is transferred. In effect, do you transfer the hardware or process or the knowledge. There is no clear answer but here we will briefly evaluate several strategies based on a review of earlier technology transfer efforts.

PRIVATIZATION

This method of technology transfer is the most visible and currently politically attractive. A government activity is transferred from the public sector to the private with the expectation that the new location will enhance organizational flexibility leading to cost reductions despite the profit expectation. For the public manager, there are two major virtues for privatization: reduction or elimination of that portion of their budget committed to a particular function and a concomitant reduction in the span of activities for which they are held accountable. Responsibility is transferred to the private entity. The most immediately politically pleasimg advantage is cost . Expenditures are reduced by removing the program or activity from the agency’s budget. The actual budget reduction achieved may be less than originally envisioned due to subsidy provisions during the transition period or guarantees of future income in order to entice private assumption of the program. Privatization in principle means total removal from the public budget, the reality proves much stickier and slower. As a result, privatization often takes more complex forms than one would expect (See Handberg, 1995: Chapter 4) .

Figure 1
Varieties of Privatization

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A. Control     A++++++++++B++++++++++C++++++++++D
               Total    Decreasing  Control--->  Total
               Public                            Private

B. Financial   A++++++++++B++++++++++C++++++++++D
   Support     Public   Decreasing  Support--->  Private
               Only                              Only
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Figure 1 provides a two-track schematic overview for the degree of separation involved during various privatization arrangements. Track A reflects the degree of public control or involvement while Track B reflects the proportion of government financial support or contribution made to the program. Point A represents a normal government program with point D at the opposite end being the optimal privatization plan when the program becomes totally private and financially responsible for all its actions. The in-between is why the process is depicted as a double-tracked system since the two variables intertwine but in fact represent separate dimensions of a single problem.

Track A references the degree of government control maintained over the privatized entity ranging from total public control to none at all. Between the two poles, one finds differing degrees of publicly imposed restrictions on the organization's operating policies and programs. For example, at point B, one finds fairly explicit and detailed requirements for continuation of certain basic services and defined levels of those services. This process can be observed in the ongoing discussions over the Shuttle contract with the U.S. Space Alliance to insure safety and reliability. By point C, the restrictions are reduced in their explicitness and intensity, allowing greater flexibility within the basic parameter that the central tasks must be accomplished (for example, continuation of Shuttle flights if the program is privatized). One should note that privatization does not entail creating a public corporation as opposed to a public agency. Such a corporation still remains a public entity rather than a private one with the flexibility that implies. The private sector includes the opportunity for entrepreneurs to profit but also in principle to fail. That failure possibility unnerves public proponents when they define certain functions as critical; e.g. shuttle flights during space station construction.

Track B references financing in that one moves from traditional total government funding to a situation involving wholly private financing through sale of services, the ultimate goal. Point B identifies government-guaranteed funding or profit (two distinct approaches) as the interaction mode --- the government's support becomes insurance against failure, although real success remains difficult to achieve because public funding usually continues restrictions on operating style or decisions. This is where the two tracks intersect most strongly, paying equates to control. Point C represents a decreasing subsidy as the government, over some defined time span, reduces its fiscal support. This weaning process is often sought by businesses due to market uncertainties and as an inducement for nervous investors. One can imagine other possible interaction combinations, this only presents a bare-bones conceptual structure.

Ideologically, privatization proposals appeal because American historical traditions advocate minimal government intervention in the economy and society. That tradition is often breached in practice but the intent remains strong. Space has long been the almost exclusive venue of government --- a situation that changes albeit slowly. One vehicle proposed for speeding that change has been privatization but it has proven a rickety bicycle upon which to journey into the future.

Government space programs have a particularly strong attraction as possible privatization venues because of their high and continuing (and to presidential administrations, unending) costs. Things are always breaking. This political proclivity is buttressed by the elaborate rationales expressed over the years regarding the economic and technological development potential embodied in a national space program. Those skills rebound back to further American productivity in other areas of the economy not just space-related industries. Such broader technological and industrial returns, for example, lie at the heart of ESA'S justification (Handberg and Johnson-Freese, 1994). Space-related privatization in principle facilitates that transfer of skills and technology back to the private sector. Remember almost by definition, privatized technology is not classified although its dissemination may be limited due to competitive concerns.

Unfortunately, the process has been rockier than one might expect in principle. The difficulty lies in the fact that the technology is government funded which creates several dynamics. These can summarized in four clusters of concerns: the high cost of operation, the convertibility issue, continued dependency on government, and consumer resistance to change. The discussion reflects a review of privatization efforts dating back to the seventies and more recent proposals regarding the Space Shuttle (Handberg, 1995).

The cost of operation and convertibility problems represent different sides of the same coin. Both reflect the fact that government space programs deemed suitable for serious privatization consideration began as prototype noncommercial efforts. The government routinely engages in demonstration projects rather than implementing operational systems suitable for immediate commercial operation. This model comes directly from NACA and continues in NASA. Such projects prove extremely useful in demonstrating the feasibility of particular space applications but in and of themselves are unlikely to be commercially viable. Many are two stage affairs, demonstration then development if the first is successful. For example, NASP-derived vehicles were to follow on completion of the X-30 project. The temptation, however, becomes to switch over the program in order not to “waste” the often large investment already made. The problem is that the underlying goals driving the original project make it incompatible for this different purpose. The why is both fairly direct and simple.

When NASA develops a specific piece of hardware such as Landsat it approaches the problem from a perspective not directly concerned with costs especially the expenses of routine operation. The system habitually has several characteristics: being overly sophisticated relative to the task at hand, very intense and demanding maintenance requirements, and virtually hand-tooled uniqueness. Overly sophisticated comes from the fact the engineer defines the task as research and development with little concern for operating efficiency. Therefore, the system reflects the experimental state of the art, which can mean significant delays and shortfalls when the new technology initially falls short. For the innovators, such delays and their concomitant expenses are not trivial but, practically speaking, are unimportant given their pursuit of the goal of technological excellence. Clementine supporters argue that demonstration technology is what the government should focus on, as it is best equipped for the task not being profit driven.

Conceptual designs are typically more difficult to build than the originators realize or care since their goal is stretching the envelope. Successful commercial projects normally operate just inside the cutting edge of technology where the operating devices are tested and reasonably reliable. Reliability is essential for successful commercial ventures, which must provide their customers the promised product on time and in usable form. Haphazard, erratic, and late delivery is a surefire recipe for economic failure. The bottom line is that merely rolling over an operating space applications demonstration program means transferring its inefficiencies and peculiarities wholesale into the commercial venture. A more productive strategy takes the results of the demonstration project and builds a new more standardized and flexible system.

Due to the preceding factors related to system costs, the interim solution often chosen has been to continue the program’s dependency on the government. This dependency takes several forms, the most prominent involve direct economic support and technology replacement strategies. Both involve defraying the costs of doing business, although the objective is approached from different angles. Cost reduction is achieved by directly transferring expenses to the public sector rather than actual elimination through achieving more efficient and effective technologies. The latter remains the long-term goal but in the short-term is a hybrid, whose survival is dependent upon government favors.

The direct economic support component usually is packaged as direct subsidies and/or insured markets. In the former, the government provides moneys directly to the business --- funding that allows a profit for this otherwise unprofitable enterprise. Such subsidies are explicitly employed in order to maintain artificially low prices for consumers. Another mechanism for providing subsidies but with the transparent fig leaf of appearing indirect is by insuring a guaranteed market. For example, prospective entrepreneurs taking over the Landsat and abortively the weather satellites were guaranteed sales of their satellites' output by several government agencies. There was no concern with fostering competition or getting the best value since the purpose was to provide funding for privatization albeit disguised as sales income. Sales organizations often employ a draw against future earnings for new personnel but with payback. Space privatization proposals never envision such a situation, emphasizing to the public the irrelevance of what they sell. The other major mechanism involves the government agreeing to provide the enterprise with the follow-on replacement technology necessary to sustain the business. This strategy was employed in the Landsat situation with mixed results. Space-related technologies are expensive to develop with a proclivity for failures, e.g. the failed launch of Landsat 6. The entrepreneur here is de facto exempted from enduring the risks and uncertainties inherent in that developmental process. Although that often proves untrue in practice.

The downside of either strategy becomes clear when one glances over the historical record. Direct subsidies are public grants which are subject to the vagaries of the political process. As key agency and political personnel, who made the original agreement, turn over, the institutional sense of commitment becomes attenuated, meaning that reduction and ultimate cancellation of the subsidy becomes very probable. Successor decision makers, searching for surplus funds to handle new and more pressing problems, find such pots of money attractive to tap. Therefore, commitments are not met and the company is cut adrift or else a continued series of crises occur.

Finally, public subsidies cut several ways, a fact often forgotten when privatization scenarios are constructed. The subsidized also include the consumers of the services or products, not just the business. Instead of a front-end subsidy, the impact is at the other end of the process. The project began as a demonstration of usefulness; therefore, consumer costs are kept low to entice participation. Resistance to price changes by consumers has been strong. Two arguments are used: one is that the public has already paid, why should they pay twice? And if the prices are raised, they are unable to afford them. Appeals against price increases are to Congress not the company since the members will respond to strong constituent demands. Economic rationality becomes a perpherial concern.

DIRECT TRANSFER

Direct transfer means the unrestricted release of public technology to the private sector for their use. Three difficulties have plagued this approach: (1) a dissemination problem, (2) a compatibility problem, and (3) a marketing problem. The first merely refers to the fact that the private sector may be unaware of the available public technology and its commercial potential (Scott, May 16, 1994). Available information may be opaque to those not engaged in the field. More critically, investigation of a possible technology may be hampered by the firm's lack of expertise. Their expertise base is sufficient for their immediate purposes but not the new possibility. Larger corporations are often indifferent to technologies they are not already engaged in working on. NASA has engaged in several outreach efforts aimed at making potential recipients aware of the possibilities.

Second, the transferred technology may require significant investment before establishing its commercial usefulness. Given marketplace uncertainties and other priorities, the technology will likely be ignored. Management horizons are not always sufficiently long to justify such a heavy commitment. Subsidy programs to assist the transfer can be too unfocused to be effective. Many firms work on the technology only as long as there is a contract, dropping it once the contract ends.

Defense reconversion has opened up many new potential products but the vendors are unfamiliar and uncomfortable with marketing such products (Anselmo, February 28, 1994). Their marketing experience is confined to a defined government marketplace, the open market is hostile and strange plus demands a different set of organizational reflexes. Applying their technologies requires an ability to adjust rapidly to changing consumer demands, a demand often created by the technology. Companies with excellent products can fail due to marketing errors. The continuing drama of Apple Computer reflects this reality. Moving from government space to civilian markets requires creation of a new marketing presence. Government programs can and do assist in the dissemination and compatibility issues but the latter remains strictly the private sector's problem.

DEVELOPMENTAL ASSISTANCE

Developmental assistance has been the strongest focus for the technology transfer effort. Several programs have operated to assist private and nonprofit organizations fully develop various aspects of space technology. For NASA, the intent has been two fold: creation of a larger user population and establishment of the usefulness of space applications in new areas of activity. Probably the most visible and troubled of those efforts are NASA's Centers for the Commercial Development of Space (CCDS). Set up in conjunction with university researchers and the private sector, the CCDS have a checkered history in large measure because the proposed projects are not always deemed truly commercial in intent. University researchers like NASA itself are often more focused on the technical advances possible rather than the commercial aspects. The most public CCDS sponsored project has been the Wake Shield Facility which flies on the Shuttle with mixed success. The program envisions manufacturing ultra pure computer chips using the vacuum of space. The difficulty is that the cost remains high compared to earth-based production processes. The performance improvement, therefore, may not be economically justified. In late 1994, a number of the CCDS were cancelled due to performance failures.

A more successful effort has been the Earth Observations Commercialization Applications Program (EOCAP) which promotes commercial remote sensing (Macauley, 1995) . The projects here have been deemed more successful because industry involvement has been more extensive and involved provision of real funding by the companies. Therefore, projects are more focused on profit potential from the beginning. NASA is placed in a more supportive role. An unstated aspect is that remote sensing as an economic enterprise has become more robust as national security restrictions on the field are reduced and the growth in concern with environmental monitoring.

SPINOFFS

Spinoffs refers simply that technologies are developed for public purposes for which entrepreneurs develop other applications; thus, creating a commercial market where none was necessarily envisioned. This technology transfer process is indirect in that the implications are not clear to the original developers. The best example currently is the application of Global Positioning System technology in a variety of commercial modes. The original space system was envisioned as an aid to military operations and search and rescue situations. Presently, there are a multitude of applications with more arising each day. For example, the grading of property for development is being made more accurate through such technology. Spinoffs can go both ways, the historic example is the development of the canning industry which had obviously military applications in allowing the storage of food for long periods in sustaining military operations. The strength of this method is the fact that the technology is employed by those who see a need, their decisions being fiscally based from the beginning. Government's role is minimal here except to make the technology accessible. This is likely to grow as defense conversion continues and companies become more sensitive to market considerations.

CONCLUSION

Technology transfer remains a difficult process because it involves predicting the future path of technological change. That means missteps occur routinely but learning from mistakes should strength the process. Privatization is a seductively attractive option but one whose pathway proves more complicated than proponents are aware or acknowledge. The other options are ones that have proven more productive over the long term.

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