Chapter 5

Operations Policy

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As previous chapters emphasize, substantially increasing the efficiency of space transportation operations, and reducing costs, will require improvements in both management strategy and the application of technology. Neither alone will be sufficient. Reducing costs will also require greater attention to launch and mission operations within the National Aeronautics and Space Administration (NASA) and the Air Force, and oversight by Congress. Although modest reductions in operations costs are possible for existing launch systems, new launch systems, especially designed for low-cost operations, appear to offer the potential for significant savings. The following discussion explores several policy options for putting the necessary technologies and management strategies to work.

IMPROVING OPERATIONS FOR EXISTING SYSTEMS

The current U.S. launch fleet consists of a range of vehicles and systems capable of placing from 440 to 40,000 lbs, into low-Earth orbit. Even if Congress funds development of a new launch system to be built in the mid to the late 1990s, the United States will continue to use most of the current fleet (with relatively minor modifications) until the beginning of the 21st century.[1] Operating the existing systems will be expensive. For example, the Shuttle system will cost the U.S. taxpayer approximately $2.5 to $3.5 billion per year (1988 dollars) for the foreseeable future.[2] Of this, some $1.5 to $2.0 billion per year will be devoted specifically to ground and mission operations. Annual operations costs for the ELV fleet could total $120 to $150 million.[3]

Congress could assist efforts within the Air Force and **NASA to reduce operations costs of current systems by using its legislative authority to require both NASA and the Air Force to purchase launch services, rather than vehicles, from private industry.** Reducing costs for Government-operated launch systems is inherently difficult because Government lacks the cost saving pressures of a competitive market environment. Nevertheless, Congress could help by requiring NASA and the Air Force to charge the costs of ELV launches to the program that uses or "owns" the payload. Congress could also use its oversight authority to conduct site visits focused on launch and mission operations, hold hearings on cost reductions, and mandate reports to Congress on the agencies' efforts to reduce operations costs.

Purchasing Launch Services Rather Than Vehicles

The Administration's latest space policy, which was released February 11, 1988, specifically directs NASA and other civilian agencies to purchase launch services rather than launch vehicles for expendable launchers, unless they require the use of the Titan IV, which is under Air Force ownership and control.[4] This policy is intended to assist the development of the private launch industry by putting the private sector in charge of the production and operation of most expendable launch systems. The policy should also have the effect of lowering operations costs for these launch systems, if launch services are procured competitively and if launch companies are given the authority to determine the most cost-effective

[1] U. S. Congress, Office of Technology Assessment, ***Launch Options for the Future: A Buyer's Guide,*** OTA-ISC-383 (Washington, DC: U.S. Government Printing Office, July 1988).

[2] U.S. Congress, Congressional Budget Office, ***The 1988 Budget and the Future of the NASA Program,*** Staff Working Paper, March ***1987.***

[3] Based on an annual launch rate of six Titan IVS, 4 Delta 11s, and 4 Atlas-Centaurs.

[4] "'Civil Government agencies will encourage, to the maximum extent feasible, a domestic commercial launch industry by contracting for necessary ELV launch services directly from the private sector or with DoD. " White House, Office of the Press Secretary, "Fact Sheet, " Feb. 11, 1988, p.9.

operations methods, consistent with safety and reliability y.

For national security space activities, the President's space policy allows the Department of Defense (DoD) to procure either ELV launch services or launch vehicles.[5] Congress could strengthen these two policies by including them in legislation. Congress could expand space transportation policy and encourage private sector competition by directing the Air Force and other national security agencies to purchase launch services rather than vehicles for all expendable launches, including the Titan IV. Such a policy would require turning over the responsibility for the operation of the Titan IV and any new launch systems to private industry.

Charging Payload Programs the Costs of Services

Space transportation costs make up a significant fraction of the total cost of a payload mission, yet within NASA and the Air Force the budget for payload design, development, and construction is independent of the budget for space transportation services. Thus, payload program managers have little direct incentive to seek reductions in transportation hardware or operations costs. One way to reduce operations costs over the long term, especially for existing systems, would be to require NASA and the Air Force to charge each payload program the recurring costs of transportation services provided. Such a policy would enable each agency and the Congress to develop a more realistic picture of the overall cost of a scientific or applications program. If payload managers had to pay for launch services out of their payload budgets, they would have greater incentive to encourage designers to design payload/vehicle interfaces that are cheaper to integrate and service.

This policy would be more effective for ELVS than for the Shuttle, because the latter is still undergoing considerable modification and many of the costs for the Shuttle are development costs. In addition, a large portion of the investment in the Shuttle is in the reusable orbiters, which function both as space platforms and launch vehicles. Apportioning costs of the Shuttle to the different users would also raise the question of competition between using the Shuttle and using an ELV.

Congressional Oversight

Reducing the operations costs of existing launch systems will require a series of evolutionary steps involving new technology and incremental changes in management strategies. Inserting new technology into current space transportation operations is costly and time-consuming. The complex procedures and myriad rules of launch and mission operations that have evolved over 30 years of the publicly funded space program are extremely difficult to change significantly, even for a new launch system, because they are so complex and interrelated, and require such varied human skills. Altering one aspect of a launch system forces other parts to change, often unwillingly. Because of these complex human and technological interactions, operations managers tend to be highly conservative in adopting proposed changes in launch procedures. Reducing operations costs will require the willingness of NASA and Air Force management to focus continual attention on inserting new cost-saving technology and innovative management strategies into operations processes. It will also require congressional oversight to assure agencies' attention to cost reduction strategies and consistent funding by Congress.

Changes of management strategy alone can yield significant savings in operations costs (see also ch. 2). For example, the Strategic Defense Initiative experiment Delta 180, which was flown on a Delta launch vehicle, demonstrated that reducing NASA and Air Force oversight and reporting requirements can decrease launch operations costs.[6] These requirements work against contractor innovation because launch services companies find it easier to keep the payload customer happy with the same "tried and true methods" than to change them. Current requirements reduce the potential for applying new technologies to launch

[5] Ibid., p. 8.

[6] Department of Defense Strategic Defense Initiative Office/Kinetic Energy Office, "Delta 180 Final Report," vol. 5, March 1987.

operations and raises the cost of launch services to the Government.[7]

Congress could assist the introduction of more efficient management methods by directing NASA and the Air Force to reduce their direct involvement in the launch process, especially for expendable launch vehicles. Congressional attention in the form of site visits, hearings, and reports to Congress would play an important part in assuring that such direction is carried out effectively. In this, as in other areas of congressional oversight, Congress should be cautious not to burden the agencies with reporting requirements that inhibit the agencies' ability to conduct efficient operations.

[7]As one launch company official that OTA queried put it, "it costs in two ways. NASA hires more people than it needs to, and we [the launch company] have to hire extra people to respond to NASA's concerns. "

FUTURE LAUNCH SYSTEMS

The most promising means of reducing the operating costs of launch systems is to develop a new system specifically designed with that goal uppermost. The Air Force and NASA are currently working on an Advanced Launch System (ALS) program with the goal of reducing the cost of launch per pound by a factor of 10 over current costs. Efficient, cost-effective ground operations are essential elements of the ALS Program, but would require considerable initial investment in new facilities and operations technology in order to realize the benefits of the ALS designs currently proposed. ALS planners are developing vehicle designs that incorporate rapid, low cost vehicle processing. Carrying out the goals of the ALS program would also require implementing a management philosophy that stresses the importance of low-cost operations.

If Congress wishes to lower the operational costs of future launch systems significantly, it must be willing to appropriate funds for the necessary launch operations facilities as new systems are developed. New launch pads and associated facilities would be needed. Many of the current inefficiencies in U.S. launch systems are the result of adding to or improving existing aging facilities. For example, many of the facilities at Johnson Space Center and Kennedy Space Center were originally built in the 1960s for Saturn 5. The Shuttle launch complex SLC-6 at Vandenberg Air Force Base was modified from a facility originally built for the Air Force's Manned Orbiting Laboratory, a program that was canceled in the early 1970s.

Some analysts have argued that the next major space transportation system, designed for low-cost operations, should be funded in a multiyear procurement that would require Congress to commit the country's resources over a period of several years, just as it does with certain weapons systems. Such a multiyear procurement could allow for larger production runs of launch vehicles and major investments in new launch operations infrastructure. This strategy could reduce the cost per unit vehicle, and provide additional incentives to design and build modular facilities capable of being modified to accommodate new technology. A recent study by the Congressional Budget Office has shown that where the development and procurement of weapons systems has been stretched out, whether because of Administration or congressional action, costs of weapons have risen. [8]The Space Shuttle program provides an excellent example of this phenomenon in the civilian space program.

However, as the OTA Special Report, *Launch Options for the Future: A Buyer's Guide,* points out,[9] such a strategy would also require the Administration and Congress to agree on long-term goals for the space program and a level of funding to support such goals. [10]

[8]U.S. Congress, Congressional Budget Office, ***Effects of Weapons Procurement Stretch-Outs on Costs and Schedules*** (Washington, DC: U.S. Government Printing Office, November **1987).**

[9]U.S. Congress, Office of Technology Assessment, ***Launch Options for the Future: A Buyer's Guide, OTA-KC-383*** (Washington, DC: U.S. Government Printing Office, July 1988).

[10]See U.S. Congress, Congressional Budget Office, The *NASA Program in the 1990s and Beyond* (Washington, DC: U.S. Government Printing Office, 1988) for a comprehensive discussion of the budgetary impacts of different development paths for the civilian space program.

TECHNOLOGY RESEARCH AND DEVELOPMENT

Research and development efforts have a continuing role in reducing costs of space transportation. The Space Transportation Architecture Study[11] and OTA's own examination of space transportation have provided a substantial list of technologies that could serve as a foundation for improved launch efficiency and lower operations costs (tables 4-1 and 4-4). Because many of these technologies would be related to those required for operating ELVS, the Shuttle or even a space station, the various governmental programs could be closely linked. For example, research devoted to the development of autonomous systems for handling hazardous substances for the Shuttle and expendable launchers could be applied to similar systems for a space station.

In order to accomplish the goals of increasing efficiency and reducing costs, Congress could authorize, and appropriate funds for, a technology development and insertion plan specifically directed toward these goals. OTA workshop participants supported the development of a national strategic technology plan designed to improve launch technologies for a wide range of launch problems and activities. A national plan would also provide interagency and interagency coordination in order to reduce any duplication of research and development being done in NASA and the Air Force.

Part of this national plan should be directed specifically at launch operations. "We need long-term objectives," said one participant, "which are handed down from the highest levels to determine where we go with the technology. I think that today a great deal of money is spent and invested in shotgun development that really has a limited yield. Budget constraints are real and are here to stay. With a well-developed strategic plan, you can accomplish a lot more with the same money that is being spent in the agencies today." Such a plan would enable NASA and the Air Force to coordinate their efforts and to focus on a variety of technologies having both near and far term payoffs.

Since the early 1970s, when NASA decided to focus its space transportation efforts on the space shuttle, the United States has invested very little in technologies that would lead to improving the efficiency and reducing the costs of launch operations procedures and payload processing. NASA's Civil Space Technology Initiative, and the Air Force and NASA Focused Technology Program that is part of the ALS program (see ch. 2, Issue B) could contribute to achieving these goals. However, they do not spend enough effort on inserting technology into operations.

A thoughtfully constructed technology development plan would generate an ongoing program of incremental improvements to launch vehicles, facilities, and launch operations. One of the goals of such a program should be to develop operations technology and procedures designed to foster routine launching. It would assist the need for improvements in current vehicle systems and support research and development of operations for advanced vehicles. A technology development plan should include work in all phases of technology development:

- *broad technology exploration (basic research)* —in areas of potentially high payoff such as automation and robotics, built-in-test procedures, and fault tolerant computers;
- *focused research leading to a demonstration* —of flight or ground operations systems such as avionics packages, expert systems, automated inspection systems; and
- *implementation to support specific applications—in* day-to-day operations. This phase should also include the development of methods to insert such technology with minimum disruption to existing procedures.

Even without a national technology plan, Congress could assist the integration of new technologies into Shuttle launch operations by providing modest additional funding specifically for a NASA technology insertion program. In addition, it could hold hearings to assess the progress NASA and the Air Force are making in coordinating ex-

[11] U.S. ***Government, National Space Transportation and Support Study 1995-2010,*** Summary Report of the Joint Steering Group, Department of Defense and National Aeronautics and Space Administration, May 1986, pp. 15-19.

isting research and development programs for launch and mission operations.

Congress could also enhance the development of new operations technologies by funding an operations test center specifically designed to carry out tests of new technologies for incorporation into existing and new launch systems (see The Role of the Private Sector, below) .12 Such a center would consist of a mock launch complex and the necessary supporting facilities for testing new concepts and technologies outside the flow of normal launch operations. It could enhance both the CSTI and the ALS Focused Technology Program and could also demonstrate the insertion of new methods, techniques, and equipment into existing launch systems.

[12] As part of its study of ALS for the Air Force, General Dynamics Space Systems Division has specifically suggested turning Launch Complex 13 at Cape Canaveral into an "ALS Operations Enhancement Center," which would be available to the entire aerospace industry—General Dynamics briefing to OTA, Mar. 15, 1988.

ESTIMATING OPERATIONS COSTS

As noted in chapter 4, projected future savings in operations costs will have to be examined carefully to assure that the costs of making the proposed changes (up-front, fixed costs) are less than the savings realized in recurring costs over the life of the program. To accomplish this, design and development of improvements to operations will require adequate cost estimation models in order for the agencies and Congress to make informed decisions about whether the proposed improvements meet cost reduction goals. As noted in chapter 3, existing cost estimation models have proven grossly inadequate in estimating operations costs. Workshop participants urged that new cost-estimating models be developed. Although the current ALS Program includes funding to support the development of accurate cost models, congressional oversight may be required to assure that the agencies focus on this issue.

Congress could require that the Air Force and NASA report on their progress in developing more accurate cost estimating models. As pointed out in chapter 3, many of the data that could be used to verify the accuracy of new models have not been gathered, particularly for launch operations. In part this has been the result of congressional and Administration cost-cutting measures. However, such measures only inhibit future cost estimation, because reliable models cannot be developed without access to this important information. Collecting and maintaining such data could be much cheaper in the long run than attempting to make decisions based on incomplete information. NASA and the Air Force should require contractors to provide this information.

A new cost estimation model should be as free as possible of potential bias. To avoid such bias, or a more direct conflict of interest, **it may be appropriate to task an independent agency such as the National Academy of Sciences, or the General Accounting Office, to develop an independent cost model.**

THE ROLE OF THE PRIVATE SECTOR

One of the difficulties the Government faces in establishing its own programs to reduce costs is that such programs generally lack the sort of incentives provided by the competitive environment of the marketplace. Until recently, the development and operation of U.S. launch vehicles were the sole responsibility of the Government. Now, however, three private U.S. firms offer commercial launch services on ELVS originally developed with Government funding—General Dynamics (Atlas Centaur), Martin Marietta (Titan), and McDonnell Douglas (Delta). In addition, three startup companies are also marketing space launch services—Space Services, Inc. (Conestoga), Orbital Sciences Corporation (Pegasus) and Amroc Corporation (Industrial Launch Vehicle).

The French firm Arianespace, the Soviet Union, and the Peoples Republic of China also offer a wide range of ELV services.

Competition among U.S. firms, and with foreign launch companies, which receive substantial go ernment subsidy, may eventually spur U.S. fir's to invest in additional facilities and technologies for reducing the cost of launch operations. However, the industry is not yet involved enough in developing new operations technologies.[13] Two Primaw factors in the existing institutional arrangements for launch operations impede privately funded innovations.

First, private launch firms only have incentive to invest in new facilities and technologies for reducing costs if the up-front investment leads to sufficient future profits. Yet launch demand for commercial payloads in the mid-1990s does not appear large enough to foster such private investment today.

Second, all current ELV launch facilities, including the safety and range components, are owned and operated by the Air Force. Private firms lease them for commercial launches on a cost reimbursable basis. Although industry can institute some cost savings measures in launch operations at these Government-owned facilities, they are constrained by the necessity to deviate as little as possible from procedures and facilities used for launching government payloads. To do otherwise would not in general be cost-effective. Unless the government encourages such investment by removing unnecessary barriers of documentation and reporting and rewarding innovation, launch firms are unlikely to assume such risks on their own,

The Government could stimulate the innovative power of the launch industry by purchasing services rather than systems; providing incentives for developing new, cost saving methods; and by providing a Government-funded operations test bed.

[13]" Space Systems and Operations Cost Reduction and Cost Credibility Workshop," Executive Summary (Washington, DC: National Security Industrial Association, January 1987), p. 2-22.

Purchasing Services

In 1985, Congress appropriated funds for the Air Force to procure an improved Titan launch vehicle (the Titan IV) to serve as a backup to the Shuttle for critical DoD payloads. By committing to purchase several vehicles at once in a "block buy," the Air Force saved money. Although the Air Force purchase of the Titan IV has stimulated the domestic ELV launch industry and resulted in savings on vehicle hardware, it has not reduced operations costs very much. In a truly competitive environment, relatively high demand for Government payloads could lead to reduced operations costs, especially if private firms had greater control over launch operations. However, block buys are not in themselves likely to result in savings on launch operations, because the Government still controls the manufacturing and launch processes.

More recently, the Air Force conducted a competition to purchase a lower capacity Medium Launch Vehicle II (MLV-2). This purchase represents a different strategy in which the Air Force purchases launch services rather than vehicles. Under this form of purchase, the Government treats launch service providers much as it treats competitive commercial procurements from any other service industry, and pays for the delivery of a payload to a specified orbit. The launch services company provides the launch vehicles and all supporting services, including launch operations. Government officials work with the launch firm to assure that the firm meets Government standards of manufacture and service. However, they limit their involvement in the details of the manufacturing and launch process. The launch firm, not the Government, accepts the financial risk of a launch failure, and guarantees a reflight or other compensation. However, because a launch failure would mean losing an expensive payload as well as a vehicle, Government officials have strong incentives to maintain current levels of launch operations oversight despite attempts to reduce oversight. They are concerned that the risk of failure and a subsequent free reflight may not be sufficient discipline for the launch firm.

General Dynamics Corporation, which won the Air Force MLV-2 competition, will provide 11 Atlas-Centaur-2 launchers and associated launch services for a firm fixed price of about $40 million each. The Government will rely on a delivery schedule, performance, and reliability guaranteed by General Dynamics. If the launcher fails for reasons associated with manufacture or preparation, General Dynamics guarantees a reflight. This arrangement will require fewer Government oversight personnel and give General Dynamics a financial incentive to improve the efficiency and reduce the costs of launch operations. Although precise figures for the savings involved are impossible to derive because this version of the Atlas-Centaur has not existed before, company spokesmen estimate this method of procurement resulted in savings to the Government of 12 to 20 percent. Savings of this magnitude are possible both because the Government makes a "block buy, " which reduces the cost of manufacturing each vehicle, and because the Air Force will not be overseeing the Atlas-Centaur production line.

Purchasing launch services rather than vehicles has not resulted in immediate savings in launch operations, in part because the Air Force still manages the launch pads. Additional savings should be possible as experience with this method of providing launch services grows. For the purchase of launch services to be most effective, the Government will have to carry through with its resolve to reduce oversight to a minimum and give private firms greater control over launch operations. Under the terms of a fixed price services contract, tasks outside the scope of the contract, such as increased documentation and reporting requirements, will cost the Government more.

Government purchases of commercial launch services offer the potential for synergism between Government and private sector attempts to reduce operations costs. The large Government purchases give private industry an assured financial base from which to work in competition with foreign firms. As the U.S. launch industry begins to demonstrate cost reductions in its commercial launch operations, some of these gains may be transferable to Government launch operations.

Incentives for Reducing Costs

OTA workshop participants pointed out that the Government agencies had been less innovative than they might have been in providing contractors with direct incentives to lower the costs of launch operations. In part, this is the result of their historical focus on the performance and safety of launch vehicles, and a desire to limit initial investment, rather than on reducing long-term operations and maintenance costs .*4

As the Delta 180 program demonstrated, cash incentives for meeting schedules can be an effective means of increasing launch operations performance (see Issue A, ch. 2). The Government could explore other possible incentives for reducing costs. Existing types of incentives do not specifically address the reduction of operations costs.

Launch Operations Test Center

As noted in the section above on Technology Research *and Development,* a space transportation operations test center could assist innovation in operations technology. NASA currently operates several aeronautics test facilities, which the aircraft industry uses on a fee basis. For example, the NASA Wallops Island facility maintains a runway and associated test facilities for assisting the private sector in improving the landing and flying characteristics of commercial aircraft. Such a facility could be operated as a Government-owned, contractor-operated establishment.

Alternatively, Congress might deem it appropriate to establish a center that is funded in part by the private sector. Such a center could be operated by a private consortium that brought together experts from private companies, the Government, and the university community.

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14 National Aeronautics and Space Adm inistrat ion, "Shuttle Ground Operations Efficiencies/Technolog, Study, " KSC Report NAS1O-11344, Boein, Aerospace Operations Co, May 4, 1987, p. 2.

Congress could also direct the Air Force and NASA to fund research within private firms to examine ways of reducing the weight and complexity of payloads. As noted in chapter 4, launch vehicles are only part of the equation for obtaining assured access to space. If launch operations costs are to be reduced significantly, there must be a complementary emphasis on reducing payload costs and simplifying payload designs. The private sector could help with these. A wide variety of new ideas have surfaced with the DoD Lightsat'[5] and ALS programs. These and related ideas should be examined for their potential applicability to lowering launch operations costs.

[15] The Lightsat program, funded by DARPA, is exploring ways to increase the cost-effectiveness of spacecraft by reducing the weight and size of payloads.

INSTITUTIONAL POLICY

Attempts to reduce operating costs in planning a new launch system would be more effective if those responsible for managing launch and mission operations and facilities were directly involved throughout the design and demonstration process. However, they must not only be involved in these processes, but have the institutional influence, or "clout," to make their views heard and acted upon. Giving operations experts broader influence over launch system planning and design will require substantial changes in the "institutional culture" of NASA and the Air Force.

New Unpiloted Launch Systems

As pointed out in chapter 4, to reap the potential gains offered by revolutionary changes in technology will also require revolutionary management changes. However, the United States is not likely to achieve the desired result if the current institutional structures of NASA and Air Force are left intact. One way to effect change in the institutional culture of launch operations and give operations personnel more influence in launch system design would be to separate the responsibility for system design and development from the operations responsibility. For example, Congress could decide to fund development of a new launch system under the management of the Air Force and NASA with the understanding **that the operation of the new launch system would be conducted by the private sector.** Under such an arrangement, the launch company would commence operation after the completion of development flights and would provide launch services to the Government on a contractual basis. In order to encourage attention to cost reduction, the company would also be encouraged to market its services to other payload customers, either from the United States or abroad.

The European Space Agency has found such an arrangement effective. When planning for the development and operation of the European Ariane launcher, " the European partners decided early to separate the functions of launcher development and operation. ESA, using the French space agency CNES as technical manager, has devoted its efforts to building an efficient, low-cost vehicle; Arianespace, S. A., a private French corporation, has focused on developing cost-effective operations (figure 5-1). Arianespace markets the Ariane launcher and provides launch services. Neither institution can proceed without the help and expertise of the other, but each contributes to the development of an efficient launch system. The result has been a relatively simple vehicle that can be prepared and launched quickly with a minimum of personnel .18

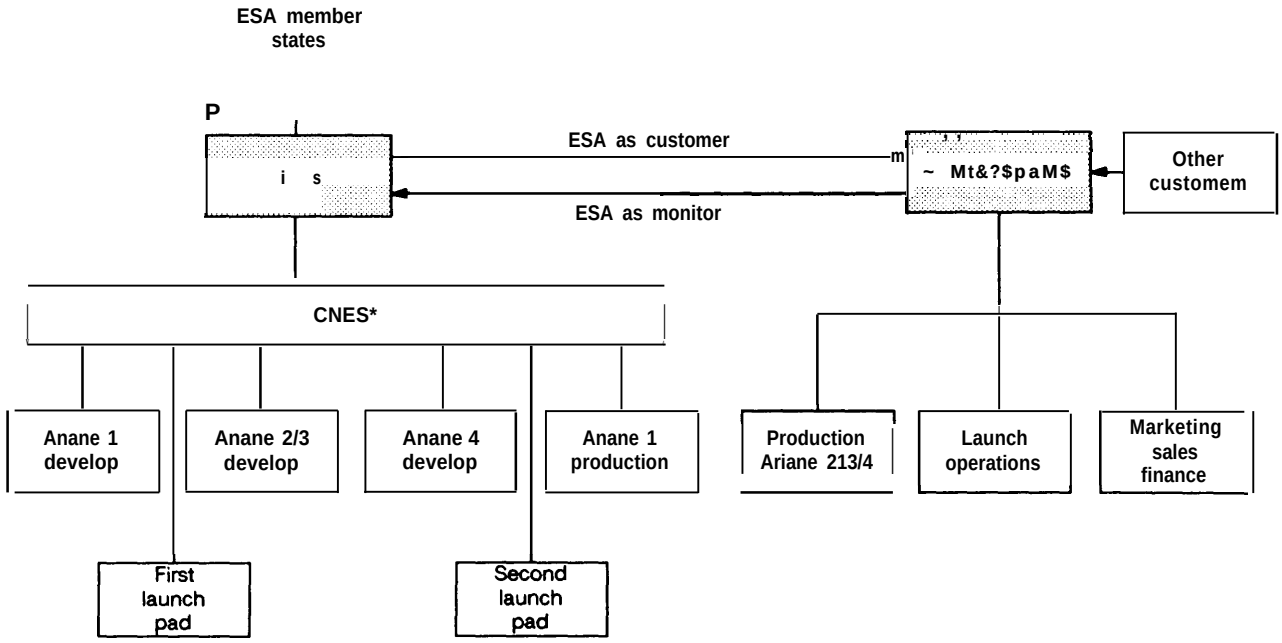
The Ariane example presents an attractive model for launch operations because it created a substantive division between the responsibility

[16] See U.S. Congress, Office of Technology Assessment, *Civilian Space Policy and Applications* (Springfield, VA: National Technical Information Service, June 1982), for a description of the development of the Ariane and the role of ESA.

[17] Because i, owns a substantial percentage of Arianespace stock, the French government has significant influence over decisions made by Arianespace.

[18] The typical Ariane 3 launch requires about 35 full-time launch personnel, plus additional personnel who assist in preparing the vehicle. The Ariane 3 typically requires about 4 weeks to assemble, integrate, and test, and 2 weeks on the pad. The Atlas-Centaur, which has approximately the same payload capacity, takes about twice as long for the same procedures.

Figure 5-1. - ESA/Arianespsce Relationship



*Centre Nationale D' études Spatiales (the French Space Agency)
SOURCE: Arianespace

and authority for development and that for operations. This institutional division gives each institution a base of power from which to work in arguing its technical case for reducing operations costs. **Because Arianespace competes in the international marketplace, it has strong commercial incentives to minimize these costs.**

In order to make such an arrangement function in reducing costs, the U.S. Government would have to purchase services rather than vehicles, provide a strong economic incentive to reduce costs, and limit Government oversight, provided the launch company proved its capacity to deliver payloads to orbit within schedule a~[d budget. The launch company would also have to assume a major portion of the economic risk of launch failure.

Such a division of responsibility would have several advantages. First, launch costs would be more visible and comprehensible than they are within the current institutional structure. Second, because the launch company would focus on launching vehicles and payloads for its clients, rather than on vehicle or payload development, it would have a major stake in limiting the number and extent of vehicle modifications that would negatively affect its ability to launch on schedule. Third, because the launch operations company would also be encouraged to compete for launch services in the international market, it would have considerable incentive to lower launch operations costs. Finally, if the ALS or other launch development program succeeds in substantially reducing launch costs, the launch firm would likely have many more private sector and foreign customers for launches than can be foreseen under existing demand projections. In general, the institutional tension that such a division of authority and responsibility would create could enhance innovation and lower costs of production.

This institutional arrangement would be successful only if the technology used in the ALS were, and were perceived to be, well within the state of the art. If significant components of the ALS pushed the limits of technology, such an arrangement would likely to be considered too risky

by both Government officials and private industry.

The arrangement would wrest much of the control the Air Force and NASA now exert over launch operations from these institutions. However, unlike earlier proposals for privatizing the Shuttle system, this policy option would not involve piloted launchers, and therefore would not encounter the objection that a private corporation should not have control over a symbol of U.S. technological prowess. In other words, this model does not seem appropriate for operation of piloted reusable research and development vehicles.

Existing Launch Systems

In the absence of a massive reorganization of the launch institutions in NASA and the Air Force, it may still be possible to focus increased attention on reducing the Government's costs of operations.

In order to assist NASA and the Air Force in reducing operations costs for current launch systems, Congress could direct these agencies to establish an operations division independent of their launch development responsibilities. In both agencies, these functions are mixed. Consequently, because budgets are also co-mingled, it is often difficult or impossible to determine what operations procedures really cost. Separating development activities from operations more clearly would allow the agencies "and Congress to focus more effectively on the true extent of operations costs. Such an institutional change has the strong advantage that it would lead to relatively few disruptions of NASA's and Air Force's current organizational structure and procedures. However, it has the disadvantage that it would force only a limited cultural change within the agencies toward operating launchers on the basis of lowered costs. This option, if pursued by Congress, would require considerable congressional oversight to assure that the agencies carried out the will of Congress. It would only work if users were required to pay launch costs.

The proposed space station is another large project in which operations costs would constitute a significant proportion of life-cycle costs. Because of its concern over the cost and management of space station operations, the National Research Council recently urged a similar organizational structure for the U.S. space station program. It has suggested "an organizational entity, independent of the space station development hierarchy, with the ultimate responsibility for operating the space station. "[19]

In any event, Congress may wish to direct the Agencies to develop a plan with the goal of giving launch operations and logistics managers a stronger voice in the design of launch vehicles. The OTA workshop on launch operations affirmed the importance of giving launch operations and logistics managers an early and influential role in the design of new launch vehicles. They should also be given greater control over the budget for operations. Most participants agreed that any design changes to current vehicles should be made with the principle of lower operations and maintenance costs as a foremost criterion.

[19]National *Research* Council, ***Report of the Committee on the Space Station*** (Washington, DC: National Academy Press, 1987), p. 34.

FOREIGN COMPETITION IN LAUNCH VEHICLES

NASA, the Air Force, and commercial launch companies should examine launch operations in other countries. U.S. agencies and companies tend to suffer from the "not invented here" syndrome. As one OTA workshop participant put it, "we in the U.S. believe that we are the leaders in technology application, and we can go off and do it as well as or better than anyone else. Thus we are reluctant to look at other nations and learn from their approaches." However, launch organizations in other countries may have something to offer in reducing operational costs.

For example, Arianespace, the commercial operator of the European Ariane launcher,[20] has focused its attention on reducing the costs of constructing and launching the Ariane, which unlike U.S. expendable launchers was originally designed as a launch vehicle not a missile. In designing the Ariane system, the European launch designers learned a tremendous amount from previous U.S. experience and used it in their own designs.

[20]The European Space Agency (ESA) developed the Ariane launcher in the late 1970s. After extensively testing the Ariane, in 1984, ESA turned over management of launch operations to Arianespace, a French corporation supported in part by the French government.

Japan has made considerable progress in developing its HI and HII launch systems. Because Japan is likely to offer the latter commercially, it will also give considerable attention to launch operations costs, especially because Japan needs a second launch center located near the equator in order to reach geosynchronous orbit more efficiently.

The United States can expect future foreign launch concepts like the U.K. HOTOL, the German Saenger, or the Japanese Spaceplane to be directed in part at commercial sales. The HOTOL and the Saenger, especially, are being designed with careful attention to improving launch operations efficiencies.