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TOWARD AN INDUSTRIAL POLICY FOR OUTER SPACE: PROBLEMS AND PROSPECTS OF THE COMMERCIAL LAUNCH INDUSTRY†

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ABSTRACT

As a result of recent problems with the space shuttle, U.S. policy has shifted from promotion of a shuttle launch monopoly to the development of a commercial launch industry. This article examines the prospects of that industry in the light of changing market conditions and increasing foreign competition. The article concludes that if current trends continue, U.S. launch providers will suffer from subsidized foreign competition and a surplus of capacity. In order to ensure the long-term competitiveness of the U.S. industry, the article recommends a cooperative government/industry research and development program, modeled on NACA or the SEMATECH consortium, to develop new lower cost launch technologies. A program of targeted government procurement, modeled on the Air Mail programs of the 1920s and 1930s should also be developed, to ensure that the new launch technologies are applied in the commercial market.

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I. INTRODUCTION

Since the tragic loss of the *Challenger*, America's space program has been thrown into a disarray from which it has yet to recover. The *Challenger* disaster, coupled with an onslaught of crippling technical problems that disabled the nation's other main-line launch vehicles,[1] resulted in a two-year hiatus in Space Shuttle launches that left many crucial military, scientific, and commercial payloads grounded, creating problems so serious that they forced abandonment of the preexisting policy of reliance on the Shuttle as America's primary launch system.[2] In response to these problems, the Reagan administration has shifted emphasis from ensuring maximum utilization of the Shuttle to ensuring the growth of a diverse, for-profit launch capability provided by commercial enterprises[3]—what is now known as the commercial launch industry.

While the various problems that resulted from the loss of a reliable United States launch capability have been serious, they have served one valuable function—they have focused attention on the importance of space launch capabilities to a wide range of scientific, military, and economic interests. Unfortunately, however, attention has been paid only to the short-term problem of how to get the U.S. launch industry moving again; little or no attention is being paid to longer-term questions, such as how to structure the industry in a way that will promote U.S. commercial launch companies' competitiveness with foreign launch endeavors—many of which are heavily subsidized by their governments—in coming decades. Given the existing launch crisis, and the short-term viewpoint of most government and industry officials, such a blind spot is understandable. But given the strategic importance of the launch industry, and the rapid growth of heavily subsidized foreign competitors, the consequences of a short-term focus are likely to be unfortunate.

In this article we take a preliminary look at the competitive prospects of the commercial launch industry over the coming decade. We discuss the technological and market factors affecting both the supply of and the demand for launch services, the ways in which those are likely to change, and what those changes portend for the U.S. industry. We conclude that the prospects for the U.S. industry are reasonably good in the intermediate term—from now into the mid-1990s—but that thereafter the industry will likely face a number of serious

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[1] *See* Matlack & Marshutz, *They Fly, We Cry*, NAT'L J., Apr. 11, 1987, at 879 (contrasting U.S. launch problems since *Challenger* accident with successes of Soviet Union and other nations); Martz, *America Grounded*, NEWSWEEK, Aug. 17, 1987, at 34-42.

[2] *See e.g.*, Matlack & Marshutz, *supra* note 1; Fallows, *America's Trouble in Space*, N.Y. REV. BOOKS, Dec. 18, 1986, at 34 (discussing U.S. difficulties); Covault, *Shuttle, Station Disruptions Slow U.S. Civil Space Program*, AVIATION WEEK & SPACE TECH., Mar. 9, 1987; *Soviet Union Takes Lead in Manned Space Operations*, AVIATION WEEK & SPACE TECH., Mar. 9, 1987, at 129; L. J. Evans, Our Nation's Commercial Space Policy: An Agenda for Action (unpublished paper presented to Washington Space Business Roundtable, Sept. 16, 1986; copy on file with the authors).

[3] *See* White House Fact Sheet, The President's Space Policy and Commercial Space Initiative to Begin the Next Century, Feb. 11, 1988; *see also* Baldrige, *Space: The Next Business Sector*, AVIATION WEEK & SPACE TECH., June 1, 1987, at 111.

problems. Partly because some foreign governments may enter the field without concern for showing a profit, there could be an excess of supply, leading many government-run launch enterprises to price below cost. The U.S. government will thus have to pay more attention to trade issues in the launch services field, and, more importantly over the long term, U.S. industry will have to show improvement over today's excessively high launch costs. In examining how this can be done, we look at government efforts to assist other nascent high-technology industries, particularly efforts to assist the aircraft industry in its formative era, from 1915 to 1960. We conclude that a combination of two policies—goal-oriented procurement and direct research support—would best serve the future of the industry. To implement this second policy we call for establishment of a government-sponsored cooperative research and development program for the space industry, similar in structure to the old National Advisory Committee on Aeronautics (NACA, a predecessor to NASA) and, more recently, the SEMATECH consortium.

II. THE STRATEGIC INDUSTRY QUESTION

Before describing the launch industry, we need to briefly consider one preliminary issue. This is the question of whether some industries are indispensable to a country because they form the foundations of entire industrial sectors—the "strategic industry" question. This may seem a digression from the topic we have set out to discuss, but it is an important digression; if the notion of especially important "strategic" industries is hollow at the core, the case for special government policies to help the space launch industry will be much weaker. If, on the other hand, special policies make sense for some key industries, we can move on to an analysis of the space launch industry, to determine whether it displays the characteristics of such a strategic industry.

As economist Richard Nelson has pointed out,[4] the strategic industry question has two dimensions. An industry may be strategic in the sense that other industries that supply its inputs or depend on its outputs—so-called "upstream" and "downstream" industries—benefit from its existence. In the extreme case, up- and downstream industries cannot function without the strate-

[4]CONGRESSIONAL BUDGET OFFICE, FEDERAL FINANCIAL SUPPORT FOR HIGH-TECHNOLOGY INDUSTRIES 3-4 (1985) (concise summary of arguments for and against strategic industries idea); R. NELSON, HIGH TECHNOLOGY POLICIES: A FIVE-NATION COMPARISON 1-5 (1984) (discussing "leading industries" concept and its history); R. GILPIN, THE POLITICAL ECONOMY OF INTERNATIONAL RELATIONS 187-90, 215-30 (1987) (discussing evolution of strategic industries concept and current thinking for and against); STRATEGIC TRADE POLICY AND THE NEW INTERNATIONAL ECONOMICS (P. Krugman ed. 1986) (in-depth analysis of strategic trade policy as an option). *Cf.* Ergas, *Does Technology Policy Matter?*, TECHNOLOGY AND GLOBAL INDUSTRY 191 (B. Guile and H. Brooks eds. 1987) (comparing technology policies of several major industrialized countries).

gic one.[5] The semiconductor industry is one example. Without it, much of the computer industry—both software and hardware—would not exist. A less drastic example comes from the aviation industry. Without modern jet transportation, such industries as travel, rapid parcel delivery, and tourism would be vastly different from what they are today.

A strategic industry in this sense is one which affects many upstream and downstream industries or at least several that are perceived as critical to national economic strength. In addition to semiconductors and aviation, economic policymakers often identify steel as one such industry, because steel is a critical component in so many of the products that make up a modern economy: automobiles, appliances, tool and die works, and armaments, to name a few.[6] Of course, every industry requires inputs, and many send their outputs to downstream industries. What makes an industry strategic, however, is the number or importance of the industries that supply it or rely on its output.

The second dimension of a strategic industry concerns economic strength at the *national* level. That is, an industry can be important not just because it helps foster other industries, but also because it gives the countries that have it an edge in the world economy.[7] To take one example, economists have argued that for a number of reasons—ranging from geographic proximity to government-coordinated supply management—a strong domestic steel industry is essential for a country to be a major participant in the world economy.[8] This was surely the thinking of the Japanese government, which after the Second World War began a largely successful effort to build the Japanese steel industry into the most efficient producer in the world.[9] And, as any of the U.S. auto manufacturers can attest, the Japanese experience suggests the validity of the strategic industry idea: without a thriving and efficient steel industry, the Japanese success in automobiles would have been much more difficult to achieve.[10]

An industry may also be considered strategic at the national level for rea-

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[5]Thus, reduced launch costs would benefit payload interests such as satellite manufacturers and operators, or telecommunications consumers. Increased launch volume, a likely result of reduced costs, would benefit those who sell to launch vehicle manufacturers. Such benefits would then, if the industry is truly strategic, "ripple" throughout the national economy. This "strategic industries" discussion does not address one important side effect of making the U.S. launch industry more efficient. To the extent that it exerts a downward force on launch prices, or makes some sorts of launches more readily available or available on shorter notice, additional efficiency on the part of the U.S. industry will offer benefits to the space science community, currently still suffering from delays and cancelled missions resulting from problems associated with the Space Shuttle. *See* Wilford, *Research in Space Falls Further Behind and Scientists are Alarmed,* New York Times, June 23, 1987, at C1, col. 1.

[6]T. HOWELL, *et al.*, STEEL AND THE STATE (1988), esp. at Ch. 1. *See also* note 14, *infra.*

[7]R. NELSON, *supra* note 4, at 1.

[8]*See generally,* T. HOWELL, *supra* note 6.

[9]*See* McCraw & O'Brien, *Production and Distribution: Competition Policy and Industry Structure,* in AMERICA VERSUS JAPAN 84-86, 92-100 (T. McCraw, ed. 1986) [hereinafter AMERICA VERSUS JAPAN].

[10]T. HOWELL, *supra* note 6.

sons of military security. In an age when wars are won on the basis of productive capacity, some might say that military security is the true rationale behind the strategic industry concept. But while there is no doubt that some industries are indispensable from a military point of view, this rationale can also be taken too far. It ignores other policy goals a government might wish to pursue. One can conceive, for instance, of a strategic industry argument in this sense being made to maintain domestic ping-pong ball or sweater manufacturing capacity—on the basis that recreation or warmth are crucial to soldiers in time of war. This might be persuasive in some quarters (for example, ping-pong ballmakers seeking protectionist legislation), but for the most part it would probably not be taken too seriously. The benefits of competition, and the possibility that entire domestic industries might be lost as a result, are simply too ingrained in our way of operating. It takes a more compelling case—actual armament manufacturing, for example, or, as in a recent case, semiconductors[11]—for this rationale to be convincing.[12]

Nevertheless, the importance of certain industries cannot be denied. Whether from a military or civilian perspective, such "building block" industries as steel and aeronautics have often received special attention from national governments. The Europeans' decision to build the Concorde SST airplane is

[11]One example is the Fairchild semiconductor acquisition brouhaha in which Fujitsu's attempt to acquire Fairchild was criticized and eventually blocked. At least one observer thought the blocked merger set a bad precedent, and warned that it could lead to increased "techno-nationalism," just at a time when the U.S. needs to increase its involvement in the international economy. *See* Reich, *The Rise of Techno-Nationalism,* THE ATLANTIC MONTHLY, June 1987, at 62. The French computer industry is another example of an industry thought to be strategic for both economic and military reasons. The French were very worried when, in the early 1960s, the U.S. began to block the export of computers to France on national security grounds; much of the subsequent development of the French computer industry can be explained as a reaction to this U.S. policy. *See* K. FLAMM, TARGETING THE COMPUTER: GOVERNMENT SUPPORT AND INTERNATIONAL COMPETITION 174 (1987).

[12]And as Kenneth Flamm has pointed out in the concluding chapter to his detailed and thoughtful book on government policy toward the computer industry, TARGETING THE COMPUTER, even when an excuse can be found the military may not be the best source of funding and guidance for an important new technology. Military perceptions of the need for new technologies shift, for example, and the military's need for concrete "deliverables" can direct the research agenda away from the most promising long-term approaches. Flamm, *supra* note 11 at 193. "Inevitably," Flamm concludes, "the long-term, the basic, the not immediately tangible are given short shrift when funding shrinks and purely military objectives are used for triage among wounded programs." *Id.* As a consequence of these and other factors, Flamm advocates the "decoupling" of civilian from military research programs. *Id. See also* Frank Lichtenberg, The Impact of the Strategic Defense Initiative on U.S. Civilian R&D Investment and Industrial Competitiveness, at 1 (unpublished paper, Graduate School of Business, Columbia University, Jan. 1988; copy on file with the authors) ("Past military R&D has made a negligible contribution to U.S. economic performance, and the exotic character of SDI technology suggests that its contribution will be even smaller."). Of course, the military is a poor source of technology policy only in comparison with as-yet-hypothetical civilian technology policy agencies. *Cf.* Solo, *Industrial Policy,* 18 J. ECON. ISSUES 697, 704 (1984) (calling for establishment of a state agency to "undertake explorative and enabling R&D"). Until these agencies are created and tested, the military can claim that it at least is doing *something* about technological competitiveness.

one recent example.[13] Japan's steel policy and Brazil's decision to build a domestic aerospace industry are two more.[14] In the U.S., the space industry is also a major source of technology and employment in its own right, accounting for nearly $25 billion in sales and 210,000 employees in 1987. While the civilian launch industry is only part of this picture, it is an important source of technology and experience.[15]

Despite their appeal to governments, strategic industry policies are often criticized by economists as irrational. An industry might bring prestige, it is argued, but that does not guarantee it is the best place for a government to spend its limited resources. In fact, a classic "comparative advantage" critique of such policies would hold that industries most rationally reside in countries with natural cost advantages. Of course, this critique ignores the reality of successful strategic industry policies; as recent experience with Japan and other nations has shown, comparative advantages are not just born, they are also made.[16] The comparative advantage critique of the strategic industries concept thus appears to embody the stereotypical economist's complaint—"it works in practice, but will it work in theory?"

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[13]One scholar has recently suggested that this decision was not as misguided as U.S. observers originally thought, since it laid the foundation for such later European successes as the Ariane launcher and the Airbus:

> From a short-run economic perspective, the U.S. planners were correct. The market proved not to be adequate at the price that had to be charged. . . . On the other hand, it was a technical success, and, in the long run, the Concorde may prove to be a very shrewd and economically profitable investment decision. First, France and Britain were not as technologically advanced in aerospace as the United States—this project provided a learning experience and kept a highly skilled labor force employed. Second, national pride in the airplane emerged and provided the nations with technological confidence.

Hertzfeld, *Economic, Market, and Policy Issues of International Launch Vehicle Competition*, in INTERNATIONAL SPACE POLICY: LEGAL, ECONOMIC AND STRATEGIC OPTIONS FOR THE TWENTIETH CENTURY AND BEYOND 203, 205 (D. Papp & J. McIntyre, eds. 1987) (hereinafter INTERNATIONAL SPACE POLICY).

[14]On the Japanese decision to build a superior steel industry, see AMERICA VERSUS JAPAN, *supra* note 9, at 93. (Steel was targeted because world demand was predicted to grow in the post-World War II era, and because "as a basic material, steel was used in such key industries as shipbuilding, automobiles, and machinery, and thus would prove essential for Japan's own domestic economic development.") *See also* T. HOWELL, *supra* note 6, at Ch. 4. On the Brazilian aerospace industry, Karp, *The Commercialization of Space Technology and the Spread of Ballistic Missiles*, in INTERNATIONAL SPACE POLICY, *supra* note 13, at 179, 183; see Whitehouse, *Brazil Shows the Way*, SPACE, Mar.-Apr. 1987, at 4.

[15]*See Space Related Employment Shows Strength*, AVIATION WEEK & SPACE TECHNOLOGY, Feb. 15, 1988, at 73. Although figures are difficult to come by, Richard Brackeen, President of Martin Marietta Commercial Titan Inc., states that the launch industry will contribute between 700 million and one billion dollars to the U.S. trade balance annually over the next few years. Remarks at George Washington University Space Policy Institute Seminar (June 20, 1988) (notes on file with author). One billion dollars in launch revenues would thus offset 100,000 foreign cars imported at a cost of $10,000 each.

[16]*See* Cohen, Teece, Tyson and Zysman, *Competitiveness*, in Vol. 3, PRESIDENT'S COMMISSION ON INDUSTRIAL COMPETITIVENESS, GLOBAL COMPETITION: THE NEW REALITY 8 (1984) ("The notion that comparative advantage can be created and not, as static trade theory suggests, just revealed, lies behind the concerted government strategies to create international advantages that are the core of development policy.") (footnote omitted). For that matter, fluctuating

Having introduced the concept of a strategic industry, we can now turn to the commercial launch industry. On the way to our final goal—prescribing appropriate policy initiatives for the industry—we have two preliminary tasks. Our first task will be to describe the launch business; our second will be to see if it fits the model of a strategic industry. We can then turn to policy recommendations.

III. THE STRUCTURE OF THE LAUNCH BUSINESS

The space launch business is only now taking shape; while it is too early to say precisely how it will look even several years from now, several broad characteristics are emerging. First, it is becoming a *business*; the era of government monopoly is coming to an end. Second, two sectors are taking shape, one dominated by very large defense firms that formerly served as NASA and military launch hardware contractors, and the other by small start-up companies developing technology and applications explicitly for commercial purposes.

As we shall see, the two sectors rely on quite different approaches to launch technology and marketing. The large firms are commercializing older rockets originally designed primarily to launch intercontinental ballistic missiles (ICBMs). Meanwhile the start-up firms are developing new, lower-cost technologies and applications aimed specifically at civilian uses. The interplay between these two classes of companies and the market will do much to shape the future of the industry, but before we consider such issues we will find it helpful to sketch in some background on the factors and events that helped create a private launch business in the first place.

A. Birth of Private-Sector Launch Services

The origin of the space launch industry is a story with three interwoven themes. The first is the shortfall in launch services occasioned by overreliance on the Space Shuttle. Second is what might be called the deregulation, or privatization, movement come to space. And third is the *Challenger* shuttle disaster, which transformed the shortfall from a bottleneck into a crisis, and gave the privatization advocates the leverage they needed to push through major changes.

Our first theme has its origins in the decision to build the Space Shuttle—a decision which the Shuttle's most careful student has called "a policy failure."[17] For a variety of reasons that had more to do with politics than with policy, advocates for the Space Shuttle were forced to sell an experimental vehicle

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exchange rates, shifts in technology, and resource depletion or glut can create very rapid shifts in comparative advantage. Thus, many scholars and policymakers believe that it may be good policy for a nation to maintain a diversified portfolio of industries so as to be less susceptible to catastrophic shocks. *See* R. GILPIN, *supra* note 4, at 215–30.

[17]Logsdon, *The Space Shuttle Program: A Policy Failure?*, 232 SCIENCE 1099 (1986).

as a cost-effective and economical way into space. These claims turned out to be impossible to substantiate, but political pressure against "wasting" money meant, paradoxically, that NASA ended up having to stick by its inflated claims regardless of the impact on later costs. In addition, constant budget cuts forced Shuttle designers to redesign the vehicle literally dozens of times over a period of a few months, with unavoidable tradeoffs between the need for reduced up-front construction costs and increased operational costs, tradeoffs invariably resolved in favor of reducing costs in the near term.[18]

As a consequence, NASA had to defend the Shuttle against not only critics but competitors as well. To guarantee the volume it needed to justify (and help pay for) the Shuttle, NASA had to seek economies of scale by trying to fly as many missions as possible, for as many paying customers as it could round up. It did this by ensuring that federal policy favored the Shuttle as the sole national launch vehicle. This measure insulated NASA to some degree from competition and guaranteed that Shuttle flights would carry as many commercial payloads as other mission constraints permitted, thus allowing the Shuttle's higher-than-hoped-for operational costs to be spread over as many customers as possible. Unfortunately, this policy also came close to extinguishing the civilian domestic launch vehicle industry.[19] In addition, in order to gain a monopoly position in launch services for government customers, NASA was forced to modify the Shuttle design yet again to meet Department of Defense requirements, a process which added substantially to the Shuttle's size and operational expenses.[20]

But the goal NASA had been forced to adopt—a monopoly in launch services—was an impossible one. Even before the *Challenger* disaster, it was becoming apparent that the Shuttle could not fly often enough to meet the needs

[18]*See* Logsdon, *supra* note 17, at 1101–03. The original configuration for the Shuttle was a "horizontal takeoff/horizontal landing" craft in which the manned, winged booster stage (somewhat reminiscent of the 747 jet that today transports the Shuttle from landing to launch sites) would be flown back to its launch point by an onboard crew while the orbiter stage continued into space. Restrictions placed by the Office of Management and Budget on NASA funding for the early 1970s, however, made development of such a craft impossible even though it would have cost substantially less to operate than the configuration eventually arrived at. As Logsdon says, "[t]radeoffs between development and operating costs characterized . . . the design process, but with much more attention being paid to lowering investment costs than to the downstream consequences for those who would have to use the system." *Id.* at 1101. *See also* M. Collins, LIFTOFF 201 *et seq.* (1988). Such pressures to reduce up-front costs are an almost inescapable result of our political system and of the practice of year-to-year budgeting. These pressures have become worse as the budget process has grown more political and the drive to produce savings (even illusory ones) in the current year regardless of the consequences to future years has become greater. A detailed analysis of what this problem portends for U.S. competitiveness in high technology areas is beyond the scope of this article, but the prospects are not good unless some measure of rationality is injected into the process.

[19]*See Commercial Space Industry Stages Major Comeback,* AVIATION WEEK & SPACE TECH., Feb. 15, 1988, at 51 ("Taking the Shuttle out of the launch business has revitalized all three American makers of Expendable Launch Vehicles (ELVs). Instead of shutting down their lines as their government contracts ran out, McDonnell Douglas, Martin Marietta, and General Dynamics are all turning out ELVs for commercial customers.").

[20]*See* Logsdon, *supra* note 17, at 1100–01.

of all its customers.[21] As former ELV contractors and private entrepreneurs started eyeing that unmet demand hungrily, NASA began to feel a good deal of pressure to change its practice of subsidizing Shuttle cargo launches.[22] Market forces were beginning to overtake the agency; demand was growing much faster than supply. The *Challenger* accident simply accelerated a process that the Shuttle design made inevitable.

Even though the Shuttle design made a commercial industry inevitable, other factors help explain why that industry emerged when it did. We will consider one such factor, the *Challenger* accident, shortly. But political forces were at work as well. In particular, the Reagan administration's penchant for privatization found its way into the space program. It is impossible to trace the origins of the private space industry without considering the political forces that helped shape it.

B. Development of a Commerical Launch Sector

The privatization movement took hold of the U.S. government in 1980, when Ronald Reagan was first elected. But it took some time for that movement to have an impact on government space policy. In 1984, the administration supported the Commercial Space Launch Act, which paved the way for the private industry.[23] Besides a general statement of support for the concept of private space launch companies, the act created the Office of Commercial Space Transportation in the Department of Transportation, a "one-stop" bureau that regulates all aspects of private launches.[24]

Since 1984, the advocates of privatization have been increasingly active. Working primarily from their bases in the Departments of Commerce and Transportation, they have shaped a number of important policy decisions that advance the privatization cause. They played a major part in the decision to permit some subsidies for private launch insurance, and they successfully advocated a requirement that government agencies rely on private launch services whenever feasible. Finally, they were said to have played a major role in the administration's recently announced support of a private unmanned space research station—the Industrial Space Facility, or ISF, now renamed the Com-

[21]The high costs of Shuttle launches, and the emergence of a nascent pre-*Challenger* disaster private launch industry are outlined in Simon & Hora, *Return of the ELVs*, SPACE WORLD, January 1988, at p. 15.

[22]The reasons why NASA, as a monopolist, was subsidizing instead of inflating prices are several. First, NASA was a monopolist only domestically, and faced stiff competition from Arianespace. Second, NASA wished to fly its shuttles as close to full as possible to generate maximum revenue. And finally, NASA was reluctant to admit how high its costs actually were. *See* Logsdon, *supra* note 17.

[23]P.L. 98-575, 98 Stat. 3055 (1984); codified at 49 U.S.C. §§ 2601 *et seq.* (West Supp. 1988).

[24]This portion of the Act codified Executive Order 12465, which had made the recently created Office of Commercial Space Transportation the lead agency in coordinating regulatory affairs concerning the private launch industry.

mercially Developed Space Facility, or CDSF. Unfortunately, this concept, like many in the field, has become a focal point of partisan bickering.[25]

But despite the importance of the Shuttle design and the growing space privatization movement in the government, the *Challenger* disaster still appears to have been the greatest causative factor in the emergence of the industry.[26] The struggling Shuttle program was stopped in its tracks, closed down pending investigations and a protracted period of soul-searching. With one stunning blow, all the compromises and concessions that had been concealed beneath the waterline of the Shuttle program came to the surface.

Meanwhile, the users of the Shuttle were stuck with no way into space, victims of the risk inherent in NASA's eggs-in-one-basket monopoly. Partly with their support, the nascent private industry was finally able to break NASA's hold on the launch business. Six weeks after the *Challenger* accident, NASA Acting Administrator William R. Graham stated that "the U.S. looks forward to the development of a viable, competitive, domestic commercial [launch] capability."[27]

This sounded magnanimous, but the Reagan administration had really forced Graham's hand. Just after the *Challenger* accident, as a result of pressure from panicked launch customers and from privatizaton activists within the Departments of Commerce and Transportation, the administration proposed gradually removing the Shuttle from the most profitable market sector, commercial communication satellite launches.[28] And, in a move that represented a complete reversal of prior policy, NASA also announced plans to acquire its own non-Shuttle launch capability.[29] Spurred by these political forces, as well as the tragic *Challenger* explosion, NASA retreated from its monopoly.

So the three themes we have identified—overreliance on the Shuttle, the privatization movement, and the *Challenger* disaster—all played a part in the birth of the U.S. private launch industry. We now turn our attention to the new industry itself. What are its characteristics? How many firms have entered? Who are the leaders?

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[25]*See Commercial Space Facility: Does Anyone Know What They Want?* INTERAVIA AEROSPACE REV. May 1988, at 409.

[26]*See Commercial Space Industry Stages Major Comeback, supra* note 19, at 51 ("Taking the Shuttle out of the launch business has revitalized all three American makers of Expendable Launch Vehicles . . .").

[27]Simon & Hora, *supra* note 21, at 19.

[28]CONGRESSIONAL BUDGET OFFICE, SETTING SPACE TRANSPORTATION POLICY FOR THE 1990S xi (1986).

[29]*Id.*, at xi. Note that under the Reagan administration's National Space Policy, announced on February 11, 1988, government agencies—including NASA—are directed to "procure existing and future required expendable launch services directly from the private sector to the fullest extent feasible." White House Fact Sheet, The President's Space Policy and Commercial Space Initiative to Begin the Next Century, Feb. 11, 1988, at 3. This suggests that the in-house NASA launch fleet will probably never be assembled.

IV. STRUCTURE OF THE PRIVATE LAUNCH INDUSTRY: U.S. COMPANIES AND FOREIGN COMPETITION

As stated above, the U.S. domestic launch industry can be divided into two broad categories: those large companies, formerly suppliers of launch equipment and support services to NASA and the military, who are now making their products available to all comers on a commercial basis, and new companies, using new launch vehicles developed on their own, who are entering the market for the first time and who often are concentrating on smaller payloads. For both groups, a major customer (in some cases *the* major customer) will remain the government, particularly the military, but the major opportunity for growth will come from private sector customers and foreign governments.

In the first group, the large companies are Martin Marietta with its Commercial Titan rocket, McDonnell Douglas with the workhorse Delta, and General Dynamics with the Atlas-Centaur. The newer companies include Space Services, Inc. with the Conestoga I rocket, which has already had a successful test launch, the American Rocket Company with an unusual solid/liquid hybrid engine design, and Conatec, which currently offers suborbital flights only. In addition LTV is making its Scout vehicle available.[30]

The technology serving the older companies has been proven over decades of use; unfortunately it is also old,[31] having been developed approximately thirty years ago, with no real thought as to cost, as part of a crash effort to catch up with the Soviet Union after *Sputnik*.[32] Although many realize that the technology in these older launchers is not ideally suited to low-cost operations, the fact that the designs are already paid for, coupled with the staggering costs associated with designing new systems from scratch, has chilled these companies' interest in designing successor vehicles for purely commercial applications.[33]

That gap has instead been filled, to some extent at least, by new companies. These startups have none of the sunk costs of the larger older firms but they also have little capital, in part because they are less active in the highly profitable defense sector. They have achieved some interesting designs,[34] and in some cases have successfully test-flown launchers, but have stuck to niche

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[30]See Figures 1 & 2 for a listing of launch companies and the characteristics of their rockets. *See also Start-up Rocket Companies Target Small Payloads*, AVIATION WEEK & SPACE TECH., Feb. 15, 1988, at 67-68.

[31]Existing launchers—the Titan, Delta, and Atlas—are all based on pump-fed liquid-fuel technology that, although much improved, remains in many ways unchanged from that of the V-2 missile of World War II. *See* THE ILLUSTRATED ENCYCLOPEDIA OF SPACE TECHNOLOGY 23-31 (K. Gatland ed. 1984).

[32]*Id. See also* Easterbrook, *Big Dumb Rockets*, NEWSWEEK, Aug. 17, 1987, at 48-60.

[33]*See* NAT'L RES. COUNCIL, SPACE TECHNOLOGY TO MEET FUTURE NEEDS (1987) esp. at 55-64.

[34]There are different approaches. Space Services, Inc. has chosen to assemble existing solid-rocket motors (Morton Thiokol's Castor and Star 37 engines) in clusters; the American Rocket Co. (AmRoc) is using its own design engine, which burns solid fuel with a liquid oxygen oxidizer,

markets such as the launch of small satellites to low earth orbit or the lofting of suborbital payloads. None of these companies is competing in the most lucrative (and most difficult) launch market, that of placing large payloads in geosynchronous orbit.[35]

In that market, foreign governments or government-supported companies compete with the larger and older U.S. companies, Martin Marietta, McDonnell Douglas, and General Dynamics. The foreign competitors include Arianespace, a European enterprise with close ties to and support from the European Space Agency and the EEC countries (particularly France), which flies the Ariane vehicle; the Soviet Union's Proton launcher; and the Chinese Long March rocket. The operators of these vehicles are competing vigorously for Western and less-developed country commercial business, and all have won at least some launch contracts, with Ariane doing the best.[36] In addition, still more foreign competition is on the horizon as Japan, Brazil, and India develop their own space launch industries. Japan's in particular is aimed at the development of low-cost commercial launch vehicles, and should be particularly ominous to U.S. concerns as Japan, unlike China, Brazil, or India, possesses the resources and expertise to compete simultaneously in the satellite manufacturing, telecommunications, and remote-sensing industries as well.[37]

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meaning that the engine can be handled like a solid fuel rocket but can be throttled or restarted like a liquid fuel engine. In addition, it cannot explode like conventional solid or liquid engines because it is virtually impossible for the fuel and oxidizer to be mixed in explosive quantities. Both companies plan modular designs that will allow rockets of varying power for different applications, although the largest payload planned is SSI's Conestoga IV which (depending on configuration) can put 600 pounds in geosynchronous orbit or 4000 pounds in 175 mile low earth orbit. *See Start-up Rocket Companies Target Small Payloads, supra* note 30; *see also* Waldrop, *Private Launch Prospects Improve,* 236 SCIENCE 766 (1987).

[35]*Low Earth Orbit* (generally abbreviated as LEO) is a term used to refer to orbits within a few hundred miles of the Earth's surface. *Suborbital* flights do not achieve orbit at all but merely curve up into space before falling back to earth. Suborbital flights do, like orbital flights, achieve zero gravity (technically "microgravity" since some gravitational effects remain present), but unlike orbital flights they do so only for the relatively short time (measured in tens of minutes at most) before they return to earth. *Geosynchronous orbits* (often abbreviated GEO) are such that the satellite appears to stay above the same spot on the surface of the earth (because the orbit's revolutionary period of 24 hours matches the rotational period of the earth) and are hence ideal for communications purposes since the earth antenna does not have to track the satellite. *Geosynchronous Transfer Orbit* (GTO) is a highly elliptical orbit from which the satellite is moved to GEO using either its own or integral upper stage thrusters. This article assumes a general familiarity with most of the technical terms involved; for more on these matters, *see* U.S. AIR FORCE, SPACE HANDBOOK (1985) (general primer on orbital mechanics, propulsion technology, and other aspects of space flight); G. REYNOLDS & R. MERGES, OUTER SPACE: PROBLEMS OF LAW AND POLICY (forthcoming from Westview Press) at Ch. 1. On small-company marketing focus *see Start-up Rocket Companies Target Small Payloads, supra* note 30.

[36]*See Proton Marketing Team Finds U.S. Interest, Opposition,* AVIATION WEEK & SPACE TECH., May 25, 1987, at 20; Covault, *New Chinese Heavy Rocket Spurs Effort To Win Commercial Launch Contracts,* AVIATION WEEK & SPACE TECH., May 4, 1987, at 22; Matlack, *Payloads for Profit,* NAT'L J., Dec. 5, 1987 at 3083, 3084–86; Simon & Hora, *supra* note 21, at 15-19.

[37]*See* Kirwan, *Japan Now Sets Its Sights on Space,* Wall Street Journal, Mar. 19, 1987, at 34, col 3; *Advanced Technology Moves Japan Toward Launcher Market,* AVIATION WEEK & SPACE TECH., Mar. 9, 1987; *Brazil's Space Program Remains Dynamic Despite Fiscal Woes,*

Figure 1

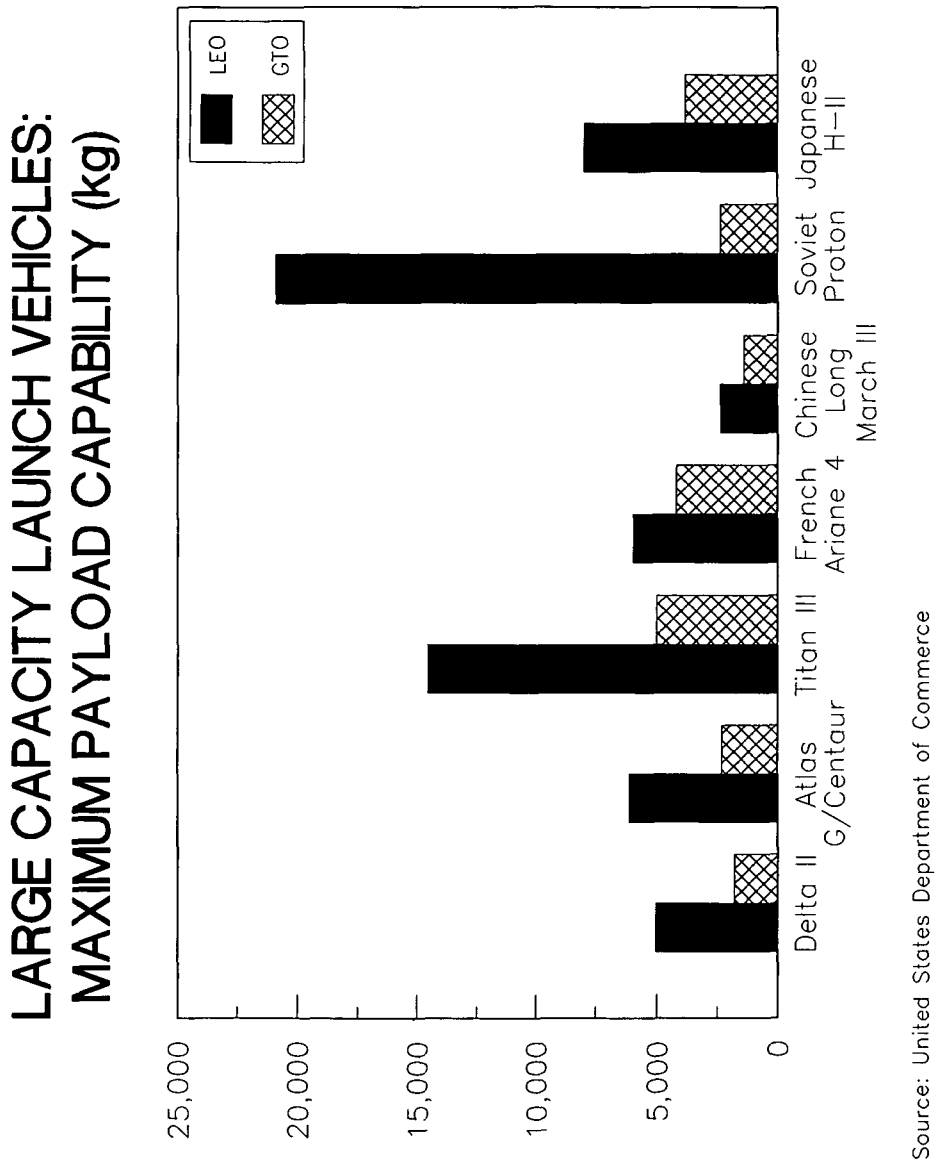
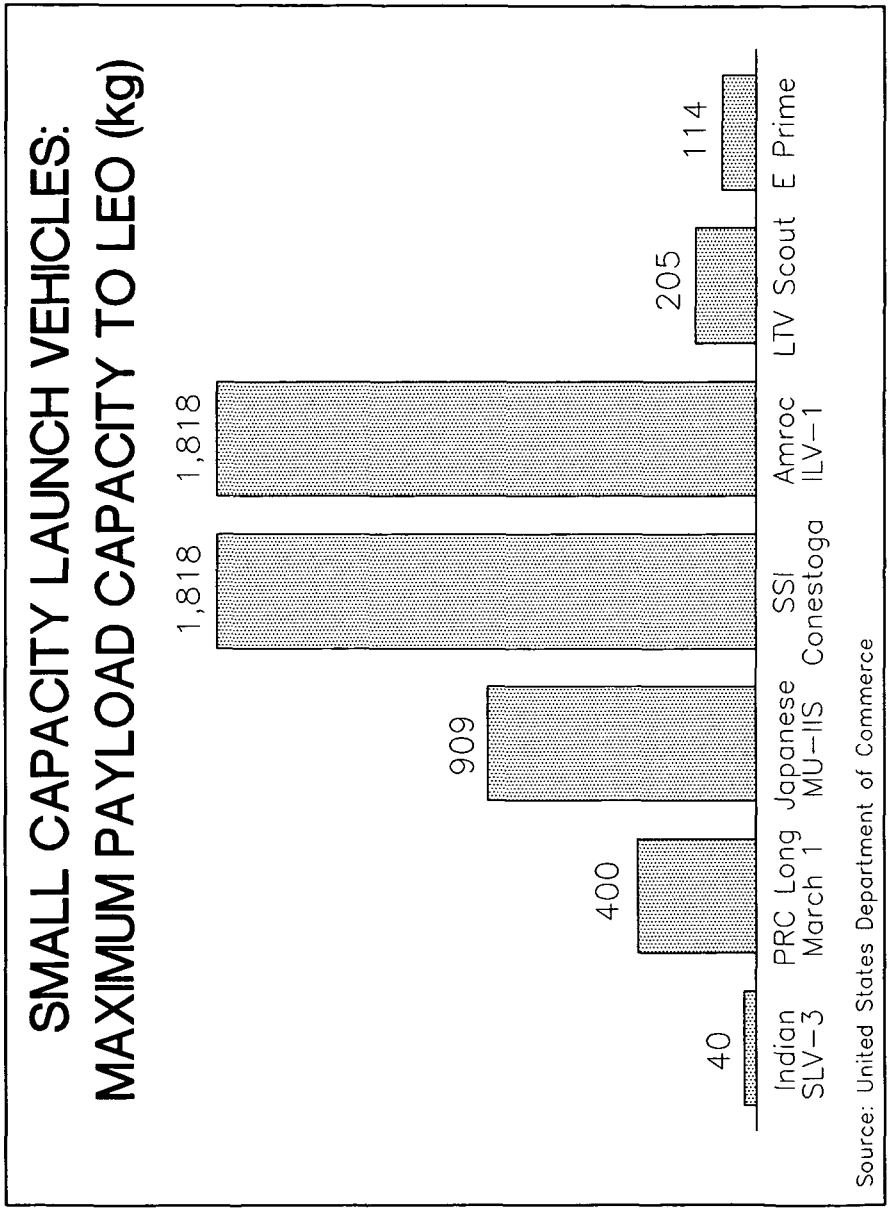


Figure 2



A. The Launch Industry Is Strategic

Why are these foreign countries, many of whom have poorly developed technology bases and other down-to-earth problems, investing heavily in developing a space launch capability? The reason is simple enough: like us, they believe that the space launch industry is a strategic one, in both military and economic terms. In military terms, the technology involved in acquiring civilian launching capabilities is very similar to that required to develop ballistic missiles. It is thus no accident that at least two of the countries developing their own launch capabilities, India and Brazil, have active nuclear weapons development programs, with India having successfully detonated a nuclear device.[38] More importantly, the technologies used in civilian launchers—precision machining, avionics, advanced metallurgy, turbine design, and so on—are generally applicable to other aerospace products, both military and civilian.[39] In addition, the launch industry provides an essential service for various activities of critical importance to both military and civilian applications, such as the launch of communications and weather satellites, the launch of military surveillance satellites, the launch of civilian remote sensing satellites for resource development and crop management, and the launch of microgravity research packages.[40] The number of industries that are "downstream" of the launch industry, along with their probable economic importance in coming years, makes the launch industry a critical component of the industrial infrastructure of the future. In this sense it resembles the classic strategic industries of the past, includ-

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Aug. 24, 1987, at 75; Tefft, *The Chariot of Indra*, AIR & SPACE, Apr.-May 1988, at 33, 37–42. The low cost of capital in Japan will also allow Japanese competitors to take a longer view than their American counterparts, giving them an additional advantage. *See* Hatsopoulos, Krugman & Summers, *U.S. Competitiveness: Beyond the Trade Deficit* 241 SCIENCE 299, 303 (1988) (High cost of capital in U.S. forces short-term view on U.S. managers; Japanese, due to high savings rate, have access to lower-cost capital and hence can adopt longer view).

[38] *See* Karp, *The Commercialization of Space Technology and the Spread of Ballistic Missiles*, in INTERNATIONAL SPACE POLICY, *supra* note 13, at 179, 182–88. *See also Nuclear Missile Development Program Revealed*, O ESTADO DE SAO PAOLO, July 10, 1982, at 1, *reprinted in* FOREIGN BROADCAST INFORMATION SERVICE, July 19, 1982, at D4.

[39] *See* Karp, *supra* note 14, at 181–82, 184 (describing synergies between space launch technology and other related technologies in military and civilian aerospace, and role of launch industry in developing technology infrastructure).

[40] These are all activities of vital and growing importance of developing countries; indeed, they are often more important to developing than developed countries. For example, most developing countries lack an established network of cable or microwave communications facilities, and often possess rugged terrain that would make such facilities prohibitively expensive. Satellite communications technology makes such problems much less significant. In addition, many developing countries lack firm knowledge of their own resource base, even though export of natural resources is often a mainstay of their economies. Satellite remote sensing often fills that need. Naturally, some developing countries are reluctant to depend on foreign concerns for such vital services. *See* Levine, *Commercialization of Space: Implications for U.S. Relations with Developing Countries*, in INTERNATIONAL SPACE POLICY, *supra* note 13, at 122–25; *Pictures Equal to Best, Madras the Hindu*, Mar. 22, 1988 at 11, *reprinted in* FOREIGN BROADCAST INFORMATION SERVICE, May 9, 1988 at 19–20 (quoting U.R. Rao, Indian Space Minister, as saying that India's "indigenous remote sensing satellite becomes imperative not only from a self-reliance point of view but also from necessity" in order to manage resources).

ing railroads and computers.[41] Ceding U.S. leadership in launch services thus would not only harm that industry, but would put other U.S. industries—such as satellite manufacturing or telecommunications—at risk.

Finally, the launch industry is an important consumer of products that are crucial to other high technology industries, making it easier for local producers of, say, aerospace-grade alloys or electronic components to obtain sufficient business to operate efficiently.[42] And, of course, there is also the likelihood that the launch industry—like other crucial industries such as railroads and aviation—will produce entirely new growth sectors unforeseen at present.[43] All of these considerations provide reasons why the industry is a strategic one, and explain why so many countries feel such a strong need to develop their own domestic launch services industry.[44]

Responding to this competition will pose a major challenge to the U.S. industry. Foreign launch enterprises, being conceived as technology drivers and as vehicles for national prestige, will not necessarily need to show a profit. Even those intended to eventually become profitable may (with their extensive government support) engage in predatory pricing in order to cripple the U.S. industry.[45] Indeed, a U.S. firm, Transpace Carriers, has already filed one trade case making just such allegations, a Section 301 action alleging that Ariane launch operations were improperly subsidized by the European Space Agency (ESA) and its member countries.[46] In this particular case, the U.S. Trade Representative ultimately declined to act on the petition, finding that the practices complained of did not differ sharply from NASA policies of the time, that the extent of the subsidy was impossible to determine, and that there was not

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[41]For a discussion of the role of railroads in establishing other important industries *see infra* notes 74–85 and accompanying text. For an excellent discussion of the downstream benefits of the American computer industry, *see* K. FLAMM, *supra* note 11, at 25–29, 32–41. *See also* Bresnahan, *Measuring the Spillovers from Technical Advance: Mainframe Computers in Financial Services*, 76 AM. ECON. REV. 742 (1986) (Estimating that the benefits to computer consumers in the financial services industries have been many times greater than the private returns to computer companies).

[42]*See* Karp, *supra* note 14.

[43]For example, the Wright brothers—or even the early sponsors of jet aircraft technology—probably did not foresee Federal Express.

[44]*See* Levine, *supra* note 40, and *Pictures Equal to Best*, *supra* note 40, regarding unwillingness of less developed countries to remain dependent on the existing space powers.

[45]This has been the case in many sectors of the semiconductor industry already. *See* T. HOWELL *et al.*, THE MICROELECTRONICS RACE 42-105 (1988). *See generally* Krugman, *A Model of Innovation, Technology Transfer and the World Distribution of Income*, 87 J. POL. ECON. 253 (1979).

[46]In 1984 Transpace Carriers, a U.S. launch service vendor, filed a Petition under Section 301 of the Trade Act of 1974, as amended (19 U.S.C. § 2411, *et seq.*), against the European governments participating in the development of the European Space Agency's Ariane vehicle. Transpace maintained that Ariane was the beneficiary of preferential treatment and subsidies. The Petition was dismissed by the President, partly on the ground that European practices did not differ sufficiently from American practices to support an action. This situation has changed, however, and the President's finding left open the possibility of further action at a later time. *See* Petition of Transpace Carriers Against the Governments of Belgium, Denmark, France, Germany, Ireland, Italy,

enough of a U.S. industry to decide whether any injury had resulted.[47] But now that the U.S. industry has developed, such issues will be harder to avoid in the future, and questions relating to U.S. competitiveness in the launch field will undoubtedly arise again.

B. The Prospects for the Market

One reason that trade frictions are likely in the future is that the commercial launch market currently encourages the entry of new suppliers, but the future demand may not be great enough to support all the new entrants. Because of the enormous backlog of cargoes, originally scheduled to be carried by the Shuttle (as well as smaller backlogs stemming from launch delays affecting other launchers such as Ariane, Titan, Atlas, and Delta), stiff competition is not likely to affect the launch industry until the early- to mid-1990s, at which time some sources predict a decline in demand.[48] If those estimates are correct, the level of competition will increase, pressure on foreign governments to price below cost in order to attract or retain business will grow, and U.S. launch companies will be squeezed.[49]

C. Prices and Costs

The competition, when it arrives, is likely to center on costs, rather than ancillary services or quality. This is because the service in question is essentially generic: placing a satellite of a particular weight in a particular orbit at a particular time. The industry is now vertically integrated, with all launch concerns engaged in the design and production of their own hardware. There are thus few opportunities for non-price competition, though some firms do benefit from a reputation for above-average reliability. Likewise, launch service consumers appear to be technically sophisticated and therefore do not rely greatly on the launch provider for the ancillary technical services. Both these factors—lack of non-price competition and little need for ancillary services—make it likely that price competition will be paramount.

And there is no doubt that the extremely high current prices leave much room for competition. A two-satellite launch on a Titan costs approximately $100 million,[50] for a cost-per-pound of over $5000. Prices for launches on

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the Netherlands, Sweden, Spain, Switzerland, and the United Kingdom and their Space-Related Instrumentalities, (filed May 25, 1984) (Transpace Petition); Determination Under Section 301 of the Trade Act of 1974, July 17, 1985, 50 Fed. Reg. 29,631 (July 22, 1985) (Administration response).

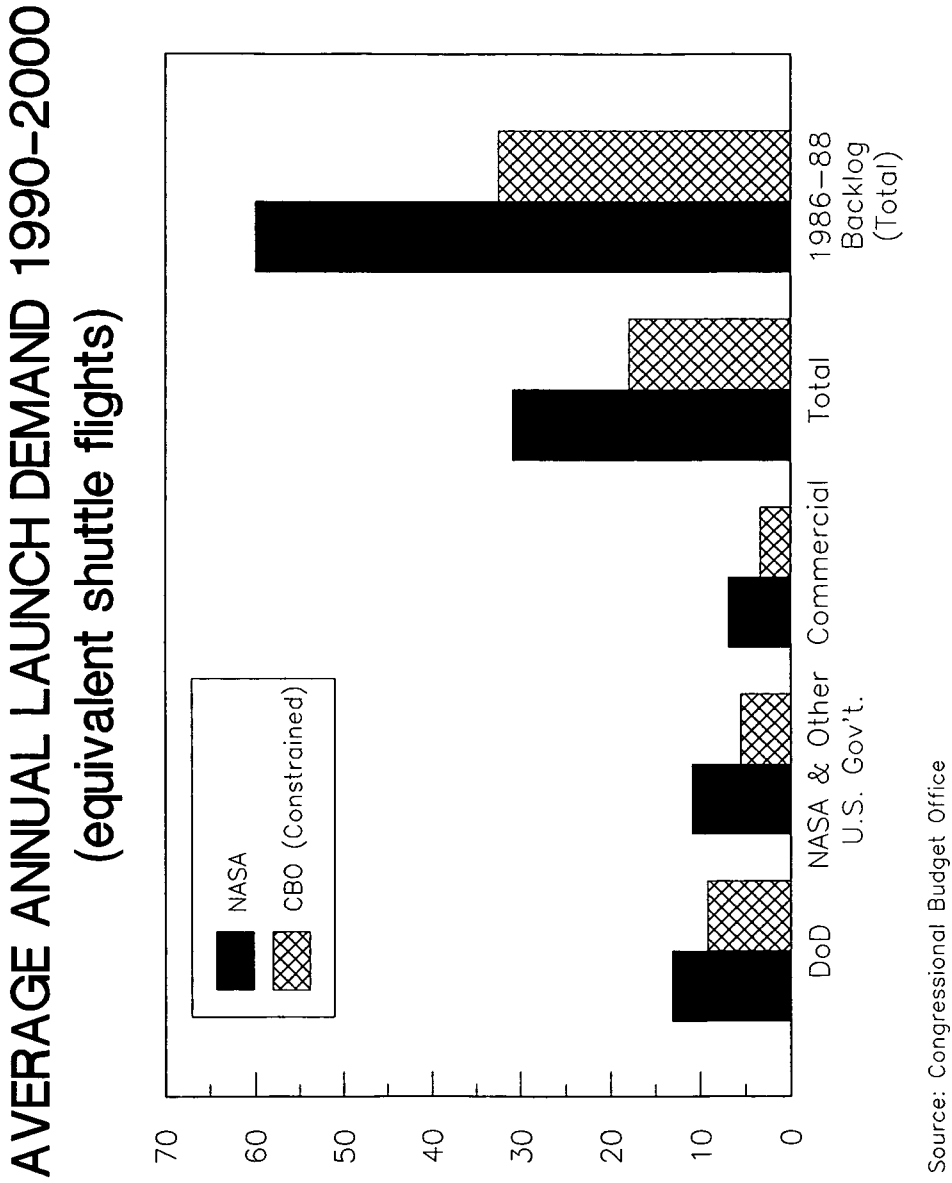
[47] *Id.*

[48] *See Commercial Space Industry Stages Major Comeback, supra* note 19; Waldrop, *supra* note 34; CONGRESSIONAL BUDGET OFFICE, *supra* note 28, at 47–48.

[49] Estimates from NASA are somewhat more optimistic than projections by the Congressional Budget Office (CBO). CONGRESSIONAL BUDGET OFFICE, *supra* note 28, at 47–48.

[50] Discounts are available in some circumstances.

Figure 3



other vehicles vary and are not entirely comparable—a rocket with low theoretical cost-per-pound which launches a payload well below its maximum weight will wind up costing more in practice than a more expensive per-pound small rocket that is loaded to its full capacity.[51] In general, though, costs for *all* launchers far exceed those that might be expected based on the physics involved.[52]

D. U.S. Trade Laws Are Not Well-Suited to the Problem

Because of the likely importance of price in this market, new foreign competitors can be expected to price aggressively, and even to dump, in order to obtain market share and scale economies.[53] Existing U.S. trade laws, however, are not admirably suited to the problem of unfair trade in launch services. The antidumping law, Section 731 of the Tariff Act of 1930 as amended, focuses on "a class or kind of foreign merchandise" that "is being, or is likely to be, sold in the United States at less than its fair value."[54] Launch services almost certainly would not be found to be "merchandise" for the purpose of this provision, nor is it likely to be found that a foreign launch provider, by contracting with a U.S. customer, has "sold" anything "in the United States." Similarly, U.S. countervailing duty law provides for imposition of a duty in response to a

[51]Cost per pound for a particular launcher is calculated by dividing the total launch cost by the maximum payload weight in pounds. To the extent that the payload weight for a specific payload is less than the maximum that the launcher can carry, of course, the actual cost per pound is greater. Launch costs thus tend to be "lumpy"—that is, minor increases or decreases in payload weight make little difference in overall cost unless they are sufficient in magnitude to require the use of a different launch vehicle. For this reason the "Shuttle Flight Equivalent" is often used as a measure of bulk launch capacity, although that measure has its own kind of awkwardness. Precise cost-per-pound figures are closely guarded as trade secrets. However, *Newsweek* magazine recently estimated the following costs: Space Shuttle–$6,800/lb.; Delta–$3,275/lb; Titan 4–$5,100/lb; Soviet Proton–$750/lb; Soviet Energia–$300/lb. Although these figures are little more than estimates, they give some idea of the magnitude of current launch costs; because of the non-market nature of the Soviet economy, however, the term "cost" means little as applied to their operations. *See For the Smart Space Shopper*, NEWSWEEK, Aug. 17, 1987, at 50. It should be borne in mind that cargoes are not freely substitutable among vehicles; large payloads, for example, may be suitable only for launch via the Shuttle or Titan. Additional information on costs and launchers is available from the Office of Technology Assessment. *See* U.S. CONGRESS OFFICE OF TECHNOLOGY ASSESSMENT, LAUNCH OPTIONS FOR THE FUTURE (R. Dalbellow ed. 1988).

[52]Indeed, it need require no more energy to launch a pound of cargo into orbit than to fly it by jet from New York to London; the craft that fly the London route are simply much more efficient. Personal conversation with Arthur M. Dula, Esq., a leading consultant and practitioner in space law, June 20, 1988. This figure is based on a study performed by Eagle Engineering of Houston. Many costs may be avoided simply by more efficient management. The Strategic Defense Initiative, for example, reportedly cut Delta launch costs in half in its Delta 180 experiment simply by streamlining management. Remarks of Richard Dalbellow, Office of Technology Assessment, at George Washington University Space Policy Institute Seminar (June 20, 1988) (notes on file with authors). Naturally, such cost-reduction methods should be explored as one way of making the U.S. industry more competitive.

[53]CONGRESSIONAL BUDGET OFFICE, *supra* note 28, at 47. *See also* Kirwan, *supra* note 37 (Japanese plans) and DeMeis, *China's Coming of Age in Space*, AEROSPACE AMERICA, May 1988, at 40.

[54]19 U.S.C. § 1673(1) (1982).

"subsidy with respect to the manufacture, production, or exportation of a class or kind of merchandise imported or sold (or likely to be sold) for importation, into the United States."[55] Both laws also apply an injury test, although in the case of the countervailing duty law the injury requirement is omitted as to countries not party to the GATT subsidies code.[56] Because these laws were designed to deal with traditional trade in goods they are poorly suited to dealing with predatory pricing in the launch services field.

Somewhat more success might be expected under Section 301 of the Trade Act of 1974 as amended. Among other things, section 301 allows the President to "take all appropriate and feasible action within his power" in response to any foreign practice that "is unjustifiable, unreasonable, or discriminatory and burdens or restricts United States commerce."[57] Unlike the antidumping and countervailing duty laws, section 301 explicitly applies to services as well as merchandise, and grants the President sweeping power to respond via duties, restrictions on foreign services, and actions in trade sectors other than the one in dispute. Thus, for example, predatory pricing in Chinese launch services might be penalized via a ban on imports of Chinese textiles or agricultural products.

Despite the power and flexibility of section 301, however, there is surprisingly little enthusiasm among space and international trade lawyers for its application to launch services. This is because in 1985 the United States refused to take action against the European Space Agency in response to the petition by Transpace Carriers, a U.S. launch company.[58] Despite this refusal to act, section 301 may profitably be applied in the future, given the changes in the industry, in U.S. practice, and in the degree and nature of foreign competition. Trade legislation specifically aimed at launch services *would* be beneficial, however, not least as a signal to foreign providers that the United States takes the matter seriously.

Another possible solution, which we endorse, would be to pursue multilateral trade talks regarding launch services with other spacefaring nations. Some such talks have been going on informally already; these could be expanded into a full-scale trade agreement governing launch services, or perhaps incorporated into the current round of negotiations under the General Agreement on Tariffs and Trade. Such talks are certainly worth pursuing and such an agreement, if well-drafted, would be worth concluding. In general, though, the effectiveness of such agreements in preventing unfair trade practices has not been stellar; at best they prevent the most egregious abuses, at worst they simply introduce market distortions that ultimately harm the competitiveness of domestic industries. To survive in the long run, U.S. launch services industries

[55] 19 U.S.C. § 1671(a)(1)(B) (1982).

[56] 19 U.S.C. § 1303(a)(1) (1982).

[57] 19 U.S.C. § 2411 (1982). Proposed trade legislation, if passed, may extend the reach and power of section 301 somewhat.

[58] *See* note 46, *supra.*

need to be better than their foreign competitors, which means that the launch technology they employ must be more efficient and at least as reliable. The policy prescriptions we outline in the next section are intended to allow the U.S. industry to meet these important goals.

V. RESPONDING TO FOREIGN COMPETITION

In order for the U.S. industry to respond successfully to foreign competition it must either become more efficient than it is now or receive a direct subsidy from the federal government. As mentioned above, we will not discuss the subsidy option since U.S. policy has generally disfavored operating subsidies (a position unlikely to change in the current deficit-ridden climate) and since little analysis is required to explain how such a subsidy would operate. Instead, we will discuss ways in which we believe the U.S. industry can be made more competitive without direct operational subsidies. Before dealing specifically with the launch industry, we will look briefly at the history of prior government efforts to promote strategic industries to see what can be learned from them.

A. Lessons from the Past: The Examples of the Railroad and Aviation Industries

Government assistance to important industries is nothing new, of course; even in the United States, where the political culture tends to look on such assistance with disfavor, it has been given repeatedly.[59] Generally speaking, the U.S. government has assisted industries in two ways: by helping to build the infrastructure necessary for them to succeed, and by helping to increase their profitability to offset the high risk of new technologies.[60]

In the case of civil aviation, the government did both. It helped build infrastructure through the National Advisory Committee on Aeronautics, a government agency that performed research into basic aeronautic technology in cooperation with industry. It also contributed to the growth of the aviation infrastructure by way of the Air Mail Acts and various military procurements and civilian market structuring efforts, which boosted demand for aircraft and

[59] *See, e.g.*, Scheiber, *The Impact of Technology on American Legal Development, 1790–1985*, in TECHNOLOGY, THE ECONOMY, AND SOCIETY 83, 87-91 (J. Colton & S. Bruchey eds. 1987); *see generally* McCrew, *Mercantilism and the Market: Antecedents of American Industrial Policy*, in THE POLITICS OF INDUSTRIAL POLICY (C. Barfield and W. Schambra eds. 1986).

[60] *See* L. FRIEDMAN, A HISTORY OF AMERICAN LAW 177-84 (2d ed. 1986) (discussing efforts of American—mostly state—governments to promote economic development during the early nineteenth century); J. W. HURST, LAW AND MARKETS IN THE UNITED STATES HISTORY 14-16 (1982) (describing Alexander Hamilton's 1791 *Report on the Subject of Manufactures* and its influence on activist, though predominantly market-oriented, government policy throughout the nineteenth century); J. W. HURST, LAW AND ECONOMIC GROWTH: THE LEGAL HISTORY OF THE LUMBER INDUSTRY IN WISCONSIN (1964); H. N. SCHEIBER, THE OHIO CANAL ERA: A CASE STUDY OF GOVERNMENT AND THE ECONOMY 1820–1861 (1969).

helped manufacturers achieve necessary economies of scale. These "demand-side" stimuli had another important effect: they created pressure for manufacturers to achieve new levels of efficiency and performance. By means of these policies, the federal government in the period from the 1920s through the late 1970s helped accelerate the development of the U.S. aviation industry. Similarly, in the case of railroads, the government acted primarily to boost the profits that would result from success—by granting rights of way that would only become profitable if the railroads became going concerns.[61]

1. *Government Support for Aviation*

Although many Americans like to believe that our country lacks a planned economy and has achieved its successes purely through the impersonal workings of free markets,[62] this is not the case with regard to one of our most successful industries, aviation. As one study says, "Judged against almost any criterion of performance—growth in output, exports, productivity, or innovation—the civilian aircraft industry must be considered a star performer in the American economy. American commercial aircraft dominate airline fleets the world over, and the air transportation industry, a primary beneficiary of technical progress in commercial aircraft, has compiled an impressive record of productivity growth since 1929."[63] Such success did not come by accident or through the workings of an unsupervised market, however, but through a series of conscious and deliberate efforts to promote the industry.

Although somewhat slow to catch on to the potential of aviation in its very early years, the federal government soon began to take the industry seriously. In 1915 it formed the National Advisory Committee on Aeronautics, which was given the bland-sounding mandate of advising the government on its military and other aviation programs. Within a few years, however, NACA had begun conducting serious research into aerodynamics and aircraft design, pioneering the use of large wind tunnels.[64]

This work led to the development of such innovations as the NACA cowl (an engine cowl that reduced the drag of bulky radial engines by nearly 75 percent), retractable landing gear, and sound aerodynamic principles for positioning engines on aircraft wings. This last discovery was essential to the development of economical transports such as the DC-3 and to the development of long-range bombers. The increased speeds made possible by better engine lo-

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[61] *See* Reynolds, *Structuring Development in Outer Space: Problems of How and Why*, 19 LAW & POL'Y IN INT'L BUS. 433, 441 *et seq.* (1987).

[62] This view is described and successfully critiqued in THE POLITICS OF INDUSTRIAL POLICY, *supra* note 59. *See also* R. NELSON, HIGH TECHNOLOGY POLICIES: A FIVE NATION SURVEY (1982).

[63] Mowery & Rosenberg, *The Commercial Aircraft Industry*, in GOVERNMENT AND TECHNICAL PROGRESS: A CROSS-INDUSTRY ANALYSIS (R. Nelson ed. 1982) at 101.

[64] *Id.* at 128.

cation made overnight transcontinental flights possible and led to greatly increased passenger appeal for the airlines.[65]

To the "push" of these technological improvements the government added a strong demand "pull" in the form of air mail contracts and military procurement. Airmail contracts, after the passage of the Kelly Air Mail Act of 1925[66] turned air mail transport (previously performed by Post Office pilots) over to private contractors, became a lucrative source of capital for airline operators and encouraged the purchase of fast, multiengine aircraft designed for long-haul service—particularly as extra "bonus" payments were made to carriers who made use of such aircraft.[67] After the heyday of the air mail service, the Civil Aeronautics Board served a similar function by establishing an environment of assigned routes and nonprice competition that encouraged airlines to purchase the latest equipment to remain competitive.[68]

Meanwhile, the military services were promoting the industry via sponsored research and procurement. Because the U.S. market in the early 1920s was saturated with war surplus aircraft, civilian manufacturing was virtually at a standstill. The military filled the gap by sponsoring "virtually every cent" of engine research in that period.[69] The military continued to support research into aircraft technology through the 1930s and (of course) during World War II. After World War II it was a major supporter of research into jet technology.[70]

Aside from direct military research support, military procurement has also been used to support the civilian industry in the post World War II period. For example, the Boeing 707 benefited substantially from the research and manufacturing expertise that Boeing acquired in the course of producing the near-identical KC-135 jet tanker and the B-52 bomber. In fact, the 707 so closely resembled the KC-135 that it shared considerable tooling, and its first prototype, like the tanker, had no windows. This synergy saved Boeing hundreds of

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[65]*Id.* at 128–30.

[66]*Id.* at 140–41.

[67]Payments to air mail operators increased from 22.6 cents per airplane mile prior to July 1, 1926 to $1.09 per airplane mile by the end of 1929—even though the prices charged the stamp-buying public were going down. The result was that aircraft purchases grew dramatically, and some manufacturers, such as Boeing with its Model 40, produced aircraft designed primarily for mail transport. The McNary Watres Act of 1930 provided the additional payments to operators who made use of multiengine aircraft, radio, and navigational aids, and gave the Postmaster General sweeping powers to merge airlines and assign routes in the interest of the industry's development. Although such payments cost taxpayers some millions of dollars at the time, they laid the foundation for fifty years of U.S. aerospace dominance. *See* Mowery & Rosenberg, *supra* note 63, at 140–41 (discussing the McNary Watres Act and its effect). For more on the history of the Air Mail Service and its importance in establishing the U.S. aviation industry, and the changes induced by the shift from government pilots to private contractors, see W. LEARY, AERIAL PIONEERS: THE U.S. AIR MAIL SERVICE, 1918–1927 (1981) esp. at Ch. 14.

[68]Mowery & Rosenberg, *supra* note 63, at 142–46.

[69]Mowery & Rosenberg, *supra* note 63, at 130.

[70]*Id.*

millions of dollars.[71] In general, military production benefits civilian manufacturers when it allows them to spread shared costs over both the military and civilian programs, and when it allows them to acquire skills that are transferable to later civilian products. In addition, it permits companies to achieve economies of scale (both static and dynamic)[72] in the production of components used by both military and civilian products.[73]

As a result of these various policies the United States aviation industry has been able to take advantage of new technologies before the industries of other countries, and has been able to exploit those technologies more efficiently. It has also been able to drive costs down and product performance up through experience and through spreading of fixed costs, making its products more attractive in the world market.

2. *Other Industries*

Aviation is a natural place to look for comparisons with commercial launch services. Both industries involve advanced technology; both require very large capital outlays; and both have military as well as civilian market sectors.

But other industries may also be instructive. We will consider only one: the railroads. This is not to say that this is the only relevant industry for our purposes; in fact, government influence has shaped a significant number of other industries in ways that might be useful to examine—in the computer industry, for example. Yet the railroad industry is the most relevant, since its history is marked by government efforts to facilitate access to the undeveloped frontier in the west, primarily by contributing rights-of-way, and since the railroad analogy is so frequently invoked in space policy discussions.

In the growth of American railroads, the government played a much smaller role than it did in aviation. But some government policies did have an impact. In the late nineteenth century, the federal government began to grant rights-of-way over portions of its huge land holdings in the west. Through these grants, the government made it possible for the railroads to reach the vast western territories.[74]

In less direct ways, the railroads received other forms of assistance; they enjoyed favorable treatment under the law of torts, for instance. Legal doctrine

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[71]Mowery & Rosenberg, *supra* note 63, at 130–31; *see also* Thompson, *Dash 80,* AIR & SPACE, Apr.–May 1987, at 62 (describing 707 prototype and Boeing's adroit use of experience gained in producing KC-135, B-47, and B-52 aircraft for the military).

[72]Static economies of scale simply result from spreading fixed costs over more units of production. Dynamic economies of scale result from moves up the learning curve that stem from greater experience. The importance of both kinds of economies is illustrated by McDonnell Douglas's unwillingness to proceed with its planned DC-11 in the late 1970s when it was unable to gain order guarantees from more than one carrier. *See The Big Deal McDonnell Douglas Turned Down,* BUSINESS WEEK, Dec. 1, 1980.

[73]Mowery & Rosenberg, *supra* note 63, at 132.

[74]*See* C. AMES, PIONEERING THE UNION PACIFIC (1969); B. JOHNSON & A. SUPPLE, BOSTON CAPITALISTS AND THE WESTERN RAILROADS (1967); R. RIEGEL, STORY OF WESTERN RAILROADS (1926); G. TAYLOR, THE TRANSPORTATION REVOLUTION (1951).

governing nineteenth century accident cases shows a clear bias in favor of the railroads.[75] While it is difficult to say precisely how much this helped the industry, it was no doubt significant to some degree. At the very least, it raised the returns to railroad investment (by externalizing the costs of accidents), and therefore made such investment at least marginally more attractive.

Perhaps most important of all government policies with respect to the railroads was in the area of competition policy or antitrust. In the earliest days of the railroads, this is more properly described as the *absence* of a policy; railroad competition—and cooperation, in the form of rate pools—proceeded without significant government intervention.[76] However, in the later nineteenth century, the Interstate Commerce Commission took a more active role in "stabilizing" rates, by acting as an intermediary in the governance of the cartels.[77]

It was not until the beginning of strong antitrust enforcement at the very end of the nineteenth century that the role of government changed. In 1897, the Supreme Court declared invalid the Trans-Missouri Freight Rate Association.[78] This decision, together with others weakening the Interstate Commerce Commission's rate-regulating authority, signalled the end of the cooperative era in the railroad industry.

Paradoxically, the result of increased antitrust enforcement was a massive increase in the concentration of the industry. Without the guarantee of stable (and profitable) rates, railroad companies felt that they had only one alternative—to build self-contained systems by acquiring their competitors.[79] After cooperation ended, the pace of consolidation was surprisingly rapid.[80]

It is difficult to reach a clear conclusion on whether government policy toward the railroads was as good as it might have been. What is important to remember is that the goals of this policy were not well articulated, if indeed there were goals to begin with. (The rise of the antitrust movement had at least as much to do with political forces as with economic policy.) So why study the railroad industry when trying to formulate policy for the commercial space launch industry? What lessons can we possibly learn from a policy adopted as much to serve political ends as to advance economic goals?

The first lesson is that basic infrastructure-building industries are worth the attention of economic policymakers. The consensus of those economic historians who have studied the railroads is that they made a tremendous contribu-

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[75]FRIEDMAN, *supra* note 56, at 468–74.

[76]*See* A. CHANDLER, THE VISIBLE HAND: THE MANAGERIAL REVOLUTION IN AMERICAN BUSINESS 81-144 (1977). Of particular interest is Chandler's Chapter 4, *Railroad Cooperation and Competition, 1870s–1880s*, which describes the efforts of the railroads to form cartels and thereby avoid "ruinous competition."

[77]*See* P. MACAVOY, THE ECONOMIC EFFECTS OF REGULATION: THE TRUNKLINE RAILROAD CARTELS AND THE INTERSTATE COMMERCE COMMISSION BEFORE 1900 (1965); G. ROGERS & I. NEU, THE AMERICAN RAILROAD NETWORK, 1861–1890 (1956).

[78]United States v. Trans-Missouri Freight Association, 166 U.S. 290 (1897).

[79]*See* A. CHANDLER, *supra* note 76, at 172.

[80]A. CHANDLER, *supra* note 76, at 166–75.

tion to the economic development of the country.[81] One point they make is of particular significance for our strategic industry analysis: the existence of a strong railroad system benefitted a large number of other, non-railroad industries.[82] Everyone from farmers to telegraph firms, whose lines were strung along the railroads' rights-of-way, shared in the benefits of railroad expansion. When these "positive externalities" are taken into account, the full value of the railroads becomes apparent.

The second lesson is that, even though the industry grew and flourished in the absence of a consistent government policy, the government did help. It was just as apparent to officials responsible for federal lands as it was to the early Interstate Commerce Commission that railroads would play a key role in national growth.

B. Space Is More Like Aviation

Thus we have evidence of an early version of today's industrial policy. (It might better be termed an *industry* policy.) But before we conclude that railroad policy is a good model to follow as regards the space launch industry we need to keep in mind the aviation industry and to review some facts about the launch industry. To begin with, the technological demands of the launch industry far exceed those of railroads. With the exception of research aimed at standardizing rail gauges and other equipment, research and design was a very minor function in the railroad industry.[83] By the end of the 1840s the technology of

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[81] *See, e.g.*, A. CHANDLER, *supra* note 76, at 81-205; R. RIEGEL, *supra* note 74. G. TAYLOR, *supra* note 74. One economic historian, Robert William Fogel, disagrees. In 1964, he published a book which concluded that by 1890 the social savings "attributed to the railroad for all commodities . . . is well below 5 percent [of the] gross national product." R. FOGEL, RAILROADS AND AMERICAN ECONOMIC GROWTH: AN ECONOMETRIC HISTORY 223 (1964). Chandler takes issue with Fogel's methodology, and echoes the conclusion of the many other historians who have rejected the Fogel thesis. A. CHANDLER, *supra* note 76, at 531 n.8. *See also* McLelland, *Railroads, American Growth, and the New Economic History: A Critique*, 28 J. ECON. HIST. 102 (1968); David, *Transportation and Economic Growth: Professor Fogel On and Off the Rails*, 20 ECON. HIST. REV. 507 (1969). In his contribution to an interesting book explicitly comparing the space program to the railroads of the nineteenth century, Fogel concludes that although the space program may not make access to space resources cheaply and widely available, space transportation differs fundamentally from the railroads in that it will open up a new territory to which *no* alternative means of transportation is available. Fogel, *Railroads As An Analogy to the Space Effort: Some Economic Aspects*, in THE RAILROAD AND THE SPACE PROGRAM: AN EXPLORATION IN HISTORICAL ANALOGY, 74, 104-106 (B. Mazlish ed. 1965).

[82] *See* Legerbott, *United States Transport and Externalities*, 26 J. ECON. HIST. 444 (1966). *See also infra* notes 113, 114.

[83] The Pennsylvania Railroad operated a research laboratory in the late nineteenth century, one of the earliest industrial R&D facilities in the U.S. *See* BARTLETT, *The Development of Industrial Research in the United States*, in 2 RESEARCH—A NATIONAL RESOURCE 26-27 (1938-1941). There were, of course, significant incremental improvements in the decades following the 1840s, but these were the result of progress up the learning curve, not active research and development efforts.

railroad transportation was essentially perfected; it changed only incrementally in the next one hundred years.[84]

This contrasts sharply with the picture of aviation we sketched above. Airplane technology, with its much larger capital requirements and technical demands, has been characterized by more continuous technological development. New designs have surely built on old ones, but unlike railroads a dominant design did not emerge quickly.

Commercial space technology, for fairly obvious reasons, is more likely to follow the pattern of aviation than of railroads. The problems that must be solved to launch payloads into space cheaply are more akin to the problems of airflight than of simple straight-line motive power. Space launch technology is in its infancy; like aviation technology, it will no doubt take a substantial period of time before it reaches high levels of economy and reliability.

Thus we can conclude that what might be termed the "railroad analogy," though useful in illustrating the importance of our topic, has a number of significant flaws with respect to providing guidance on how to promote the commercial space launch industry. As we have seen, railroads contributed mightily to the infrastructure of the growing nation. In similar fashion, a reliable space launch capability would contribute greatly to the formation of a "space infrastructure." And, as with the railroads, service into space would probably benefit a wide number of industries, thus generating externalities above and beyond its own intrinsic value. But space launch services and railroads differ in respect to their underlying technologies. Space launches, like aviation, center around a more complex technology, one that will likely take longer to perfect than railroads.

As a consequence, the historical analogy between launch services and railroads may well be less useful for policy-analysis purposes than comparisons between such services and aviation. This is not to say that the railroad analogy is without merit, however. At the broadest level, railroads may well turn out to provide the best comparison to the entire space transportation venture. Assuming space transportation eventually becomes as routinized as railways, it will fulfill the same role in opening up space as the railroads did in opening up the western United States. And no doubt much of the same pioneering spirit that characterized western expansion will be called for in early space development.[85] But, at least in the early stages of space launch service, before the tech-

[84] Alfred Chandler describes it this way:

> During the 1840s the technology of railroad transportation was rapidly perfected. Uniform methods of construction, grading, tunneling, and bridging were developed. The iron T rail came into common use. By the late 1840s the locomotive had its cams, sandbox, driver wheels, swivel or bogie truck, and equalizing beams. Passenger coaches had become "long cars," carrying sixty passengers on reversible seats. Boxcars, cattle cars, lumber cars, and other freight cars were smaller but otherwise little different from those used on American railroads a century later.

A. CHANDLER, *supra* note 76, at 82–83 (footnote omitted).

[85] On the usefulness of the railroad analogy in this broader sense, *see* Reynolds, *supra* note 61, at 445–47.

nology stabilizes and routine, reliable service becomes available, aviation would seem to provide a better model.

With this in mind we can now turn to the prescriptive portion of the article. Building on the lessons of the aviation industry, we propose a number of government policies aimed at assisting the commercial launch industry. By drawing from the record of the aviation industry, we hope to foster the development of space launch services that will become as reliable and routine as the railroads.

VI. BUILDING A LAUNCH SERVICES INDUSTRY THAT WILL LAST

If America is not to become the Portugal of outer space, opening up new routes that will be exploited mostly by other, later entrants, then it must maintain a strong launch industry capable of assuring reliable and reasonably priced access to space. In addition, as we have discussed above, a strong space launch industry is likely to be essential to remaining competitive in a variety of closely linked industries. But it is one thing to *say* that an industry must remain competitive and another to say how that is to be achieved. Our views on what should be done follow.

A. Avoiding Unfair Foreign Competition

As mentioned earlier, the existing backlog of payloads means that all available launchers will be operating at or near capacity for several years.[86] This provides an opportunity for negotiations at a time when nations are not scrambling to enlarge their pieces of a shrinking pie. There is thus an opportunity for a meaningful agreement that will be harder to achieve under less favorable circumstances. The United States may be able to blunt the impact of foreign government subsidies if it is able to negotiate such an agreement, thus buying the U.S. industry some additional time.

Such an agreement will not solve all the industry's problems, however. The history of trade agreements in recent decades has not been a happy one, and the inherent difficulties in costing large and complex technological enterprises such as civilian launch services mean that even in the presence of an agreement not to price below "cost" there will be substantial opportunity for improper subsidies.[87] By itself, an agreement on launch pricing is thus unlikely to be of substantial benefit to the U.S. industry over the long term; instead, it is likely simply to make dumping and unfair subsidies a bit more difficult in the

[86] *See supra* notes 48–49 and accompanying text.

[87] This is amply borne out by the United States' domestic experience with the Shuttle debate. *See supra* notes 26–29 and accompanying text. *See also* Ledyard, *The Economics of the Space Station*, in ECONOMICS AND TECHNOLOGY IN U.S. SPACE POLICY 127 (M. Macauley ed. 1987) (describing difficulties in determining cost for space activity).

short term. Over a longer period the only way for the U.S. industry to remain competitive is to be more efficient than its foreign competitors. That will require constantly improving technology and scale economies of the sort that have given the U.S. aviation industry its lead.

B. A Policy for Developing the Industry

As was discussed above,[88] the federal government promoted the competitiveness of the aviation industry through a combination of technological infrastructure and demand-inducing efforts that promoted efficiency among U.S. producers. The same needs to be done with regard to the launch industry. Following are some suggestions for translating these general principles into specific policy.

1. *Encouraging Research and Development*

Most of today's launch vehicles are based on designs that are decades old and that were never intended to minimize costs.[89] In order to remain competitive, the U.S. industry will have to invest in newer, more efficient designs and operational techniques. Although a few small companies are beginning to do just that, none is focusing on the most lucrative and important market, that for placing large communications satellites in geosynchronous orbit. If the United States is to continue as a major presence in this market design work needs to begin soon on less-expensive successors to the aging fleet of Titan, Delta, and Atlas launchers. The task of federal policy will be to encourage such work.

One way to do so will be for the federal government, perhaps in cooperation with industry, to conduct and promote research in new and more efficient technologies. This is already being done on a very small scale as government agencies make some facilities available to launch companies[90] and the recently released National Space Policy calls for more such cooperation.[91] Such fairly passive efforts, however, are only a start: the federal government must sponsor direct research into technologies (such as pressure-fed boosters, etc.) designed to lower costs and improve reliability for the civilian market. Such research should also focus on more efficient operational and management techniques, which themselves may result in significant savings.[92]

There are a variety of potential models for such research. One is the NACA, which both provided test facilities for the use of aircraft producers

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[88] *See supra* text accompanying notes 63–73.

[89] *See supra* notes 31–33 and accompanying text.

[90] The American Rocket Company, for example, has been allowed to use Air Force test stand facilities at the Air Force Rocket Propulsion Laboratory at Edwards Air Force Base. *See Start-up Rocket Companies Target Small Payloads*, *supra* note 30, at 67.

[91] *See* White House Fact Sheet, *supra* note 3.

[92] One area in which the government helped lay the technical groundwork for American industry domination of an entire field was in the area of geosynchronous communications satellites, where NASA, fulfilling a role more suited to its predecessor NACA, worked with industry to de-

(such as the famous Langley wind tunnels) and conducted basic research on its own.[93] Perhaps a federally sponsored research program into commercial launch technologies could combine those functions as well. We discuss ways in which that might be done below.

Another model is the recently formed SEMATECH consortium designed to conduct research into semiconductor manufacturing technology, a field in which the U.S. industry has lost its edge to Japan. In SEMATECH, the research into manufacturing technologies is conducted primarily by the SEMATECH entity itself at its Austin, Texas headquarters, with funding coming from the industry and the government. Research results are then disseminated first to the participating companies, giving them a time advantage over foreign competitors.[94]

The precise structure of a launch technology initiative should be worked out in consultations between government and industry, since such an initiative is much more likely to work if it clearly serves the needs of both. Key considerations, however, can be identified in advance. They are:

- *Appropriating the Value of Innovation*: It is a cornerstone of modern innovation theory that innovators, to be successful, must capture at least part of the value of their ideas—enough to make the effort worthwhile.[95] Any research consortium must therefore ensure that American companies in the field are able to make use of its developments before such innovations are taken up by foreign competitors. In the case of some innovations, simple scale economies and retooling costs will be enough to prevent foreign companies from catching up too quickly;[96] for others, some sort of secrecy regime may be needed.
- *Long and Short Term Views*: It may well be that within a few decades the

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velop the technology used in geosynchronous satellite communications. The geosynchronous satellite concept was first proposed by Arthur C. Clarke in a 1945 article in *Wireless World* (for which reason geosynchronous orbits are now often called "Clarke orbits"), but American proponents of the concept encountered considerable resistance, particularly from powerful sources within Bell Laboratories. NASA was persuaded to explore the technology, however, and succeeded in neutralizing resistance from the Defense Department, which previously had a monopoly on the development of satellite communications technology because of its obvious military potential. With its SYNCOM series of satellites, NASA, in cooperation with Hughes, successfully developed a low-cost alternative to previously proposed sytsems, leading to U.S. industry dominance of the communications satellite construction industry that exists to this day. *See* Teubal & Steinmuller, *Government Policy, Innovation and Economic Growth: Lessons from A Study of Satellite Communications*, 11 RES. POL'Y 271 (1982). A similar effort in the area of launch technologies would be very worthwhile, although it is not clear that NASA is the appropriate agency to conduct it. *See also supra* note 52 (discussing savings from more efficient operations and management).

[93]*See* discussion at *supra* notes 63–70 and accompanying text.

[94]*See generally* CONGRESSIONAL BUDGET OFFICE, THE BENEFITS AND RISKS OF FEDERAL FUNDING FOR SEMATECH 39-43 (1987) (DESCRIBING SEMATECH).

[95]Teece, *Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy*, 15 RES. POL'Y 285 (1986). *See also* Katz, *An Analysis of Cooperative Research and Development*, 17 RAND J. ECON. 527, 541-42 (1986) (finding increased efficiency in cooperative research and development).

[96]This is the case in the airframe industry, for example. R. Levin, A. Klevorick, R. Nelson & S. Winter, Survey Research on R&D Appropriability and Technological Opportunity: Part I, Appropriability (unpublished manuscript, 1984, on file with authors). *See also* Mansfield, Schwartz & Wagner, *Imitation Costs and Patents: An Empirical Study*, 91 ECON. J. 907 (1981).

primary method of placing cargoes in orbit will not be chemical-fueled rockets, but such other technologies (now only experimental) as laser or electromagnetic launch.[97] Although focused primarily on near-term technologies, any research program must explore such alternatives to avoid being left behind over the long-term by new generations of launch technology.

- *Concern for Payload Interests*: Because the commercial launch industry is a vital input for other industries such as communications, microgravity research, and satellite manufacture (not to mention space science, which is not an industry *per se*), research should take close account of the needs of those customers. It may be possible to identify future needs that would not be served by existing technology, thus gaining an advantage once those needs become actual. It might therefore be worthwhile to include representatives of the satellite manufacturers and of key launch customers in discussions regarding research priorities.
- *Open Participation by U.S. Entities*: In order to prevent a cooperative research effort from becoming a cartel on behalf of existing launch providers, the system should be easily accessible to new entrants, so long as they are part of the U.S. industry. Since the point of such a venture is to help the U.S. domestic industry, however, foreign-country participation should be allowed, if at all, only subject to very close reciprocal cooperation and disclosure agreements.
- *Defense Department Involvement*: Since the Defense Department is a very important launch customer, it should certainly have some involvement in any research program. Its involvement should, however, be solely in its capacity as an important commercial customer—the red tape, security, and other disadvantages of Defense projects should be kept far removed from any commercial research venture. Of course, the U.S. government (including the Department of Defense) should have access to the new technology developed.[98]

These are what we consider to be the main considerations in designing a research program to maintain competitiveness in the commercial launch industry. Others may appear upon close examination by members of the industry and government officials.

With regard to how such a program should be structured and what government agency should be primarily responsible, we have the following thoughts. In some ways, the logical choice as a coordinating agency is NASA: it is the lineal descendant of NACA, of which we (and others) have spoken highly; it has done important rocketry research work in the past; it played the major role

[97] *See, e.g.*, Kantrowitz, *Propulsion to Orbit by Ground-based Lasers*, ASTRONAUTICS & AERONAUTICS, May 1972, at 74.

[98] Note that a disengagement from Defense Department activities was essential to the success of NASA's SYNCOM program, although it did benefit from the lessons learned in the Army's ADVENT geosynchronous program, which was ultimately unsuccessful. Teubal & Steinmuller, *supra* note 92, at 274.

in developing the technology of geosynchronous communications satellites;[99] and its name is still synonymous with space to most people. On the other hand, NASA has been regarded by many (and still is by some) as an enemy of private launch services, and many bitter feelings remain from the days of the Shuttle monopoly,[100] feelings that could poison any endeavor led by NASA.

Another possible candidate is the Department of Defense. Given Americans' discomfort with government action on behalf of industries for commercial reasons, many such programs have in the past been linked to defense for largely political reasons and (unlike some other examples) it is certainly true that the maintenance of a vigorous domestic launch industry is vital to national security. By now, however, Americans seem to be waking up to the importance of maintaining industrial position for purely economic reasons and the red tape and bureaucratic inertia likely to accompany Defense Department supervision are likely to be crippling; as stated above, Defense Department involvement should reflect its position as a major commercial customer, but no more.

Another possibility is the Department of Transportation, whose Office of Commercial Space Transportation regulates the private launch industry.[101] OCST's regulatory role, however, is likely to present conflicts of interest that would undercut its suitability for managing a research and development enterprise involving the companies it regulates. At any rate the OCST has no expertise in managing high-technology enterprises, although its staff does possess considerable familiarity with the industry. Lastly among existing agencies, the Department of Commerce, which in recent years has been a tireless advocate for the private launch industry, might be a candidate. Commerce, however, also lacks expertise in managing sophisticated research and development exercises on this scale, although it does operate substantial Research and Development enterprises through the National Oceanic and Atmospheric Administration (NOAA) and the National Bureau of Standards.

Having suggested that existing agencies are less than ideal candidates for the management of a research project dedicated to developing new technology for the launch industry, we feel that it is only fair to make our own suggestion. For a variety of reasons, we believe that the appropriate body for coordination of such an effort would be a newly reconstituted National Space Council, headed by the Vice President, operating out of the Executive Office of the President, and drawing upon the technical and managerial skills of the above departments (all of whom have a great deal to contribute). Such an entity would lack the long and often unhappy history that plagues some of the other agencies, but would have access to the best talent now available throughout the govern-

[99] *See* Teubal & Steinmuller, *supra* note 92.

[100] *See, e.g.*, Foley, *Government Faulted for Frustrating Commercial Space Entrepreneurs*, AVIATION WEEK & SPACE TECH., Feb. 15, 1988, at 66 (describing complaints concerning NASA treatment of private launch companies); Simon & Hora, *supra* note 21.

[101] DoT has this authority under the Commercial Space Launch Act of 1984, P.L. 98-575, 98 Stat. 3055, codified at 49 U.S.C. §§ 2601 *et seq. See also* Commercial Space Transportation Licensing Regulations, 53 Fed. Reg. 11004 (Apr. 4, 1988).

ment. Just as importantly, it would have access to the centers of power within the Executive branch, ensuring a greater likelihood of real cooperation from whatever agencies are involved.[102]

Of course, these thoughts are just that, and it is entirely possible that some existing agency would be an adequate center for such a program. NASA, despite its recent problems, remains at least in theory an agency devoted primarily to research and development. Under a new Administrator, and with new priorities, it might well outlive the residual hostility over Shuttle pricing and related brouhahas. And NASA certainly possesses the technical expertise and proud history to succeed in such a project. Similarly, the Department of Defense might be able to serve as a center for research of the sort we describe. In a limited way it is already doing so, through the Defense Advanced Research Projects Agency's LIGHTSAT program, which involves research into lightweight low-cost satellites and the launchers needed to get them into space.[103] Other government entities, such as the National Laboratories, the National Science Foundation, and the National Academy of Engineering, might well also play an important role.

Regardless of how responsibilities are assigned, however, we believe that overall supervision should be at a high level. The reconstitution of the National Space Council, which already has been suggested by many legislators and Presidential candidates, would ensure that this would be the case. The activities and agencies necessary to get the space industry on a first-class competitive footing will be many and the need for coordination great; only the political clout associated with top-level management can ensure that bureaucratic rivalry and inertia, or legislative indifference, will be overcome.[104]

2. *Encouraging Application of Results*

It is not enough, however, to develop new technology—active efforts are required to speed its introduction in the face of inertia, sunk costs, short-term profit pressures and the "not invented here" syndrome. In the aviation field, this was done via procurement. For example, the air mail contracting scheme included preference for and extra payments to contractors who made use of modern innovations such as multi-engine aircraft, radio, and various navigational aids.[105] In the same way, federal procurement of launch services should give preference to launch operators who make use of new innovations devel-

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[102]For all space-related issues, given the relative paucity of grassroots support and the dependence of most commercial aerospace firms on Defense Department contracts—in other lines of business even if not in space—the President is the only source of political power sufficient to overcome inertia and accomplish major goals.

[103]*See DARPA to Award Launcher Contracts,* AVIATION WEEK & SPACE TECH., Feb. 15, 1988, at 69 (describing LIGHTSAT launcher procurement and related Air Force program for a "Single Purpose Inexpensive Satellite," or SPINSAT, and associated launcher). *See also* Morrison, *Beating the Space Crisis,* NAT'L. J. Mar. 28, 1987, at 756.

[104]For a discussion of these political issues from an academic perspective, see Cohen & Noll, *Government R&D Programs for Commercializing Space,* 76 AMER. ECON. REV. 269 (1986).

[105]*See* note 67, *supra.*

oped through research.[106] Thus procurement would not simply help provide launchers in general with government contracts, but would favor those sectors of the industry that would be most competitive for foreign business, as the Japanese did in promoting steel industry research and development.[107]

3. *Other Efforts*

In a more general way, too, government activity should be examined and to the extent feasible, conducted in ways to promote the industry. For example, many analysts have suggested that the Defense Department shift from its current policy of relying on a relatively small number of vulnerable, multi-role satellites to a policy of relying on many simple single-role satellites, thus blunting the danger from Soviet or other foreign anti-satellite systems.[108] While such a decision is (and should be) largely a military one, decision makers should also note the favorable impact that such a shift would have on commercial launch companies, since it would mean hundreds of low-cost launches on smaller launchers between now and the end of the century, allowing both established enterprises and start-up companies like AmRoc and SSI the opportunity to move up the learning curve and exploit economies of scale.[109]

In a more general way, various legal issues surrounding the launch industry should be examined to ensure that there are no unnecessary barriers to its success.[110] A number of areas, from tax to insurance,[111] to questions regarding

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[106]To a very limited degree this is being done already. *See* Verity, *Unleashing America's Space Entrepreneurs*, ACROSS THE BOARD, Apr. 1988, at 23-27 (describing government procurement as a key driver of new industries; Verity does not, however, discuss the carefully targeted use of procurement we are advocating). In the aviation industry, Civil Aeronautics Board promotion of non-price competition played the same role by forcing airlines to maintain new fleets in order to attract customers. *See supra* note 68, and accompanying text.

[107]*See* T. McCraw & P. O'Brien, *supra* note 9, at 92-100 (Japanese encourage efficiency by tying steel procurement policies to producers' efficiency in manufacturing steel).

[108]*See* P. STARES, SPACE AND NATIONAL SECURITY 183-86 (1987).

[109]*See* Reynolds, *National Security on the High Frontier*, 2 HIGH TECH. L.J. 281, 284 (1988). *See also Start-up Rocket Companies Target Small Payloads*, *supra* note 30, at 67 (describing market potential of DoD shift to smaller satellites); *Payloads for Profit*, *supra* note 36.

[110]The federal government has been bitterly criticized for its interference—often on grounds of national security, sometimes as a result of inattention or bungling—with the growth of commercial space companies. *See, e.g.*, Foley, *The Broken Promise of Commercial Space*, AVIATION WEEK & SPACE TECH., Sept. 14, 1987, at 15; French, *Paperwork is a Launch-Vehicle Roadblock*, AEROSPACE AMERICA, Apr. 1988, at 16.

[111]Currently, private launch companies are required to carry extensive third-party liability insurance, insurance that their foreign competitors receive on a subsidized or free basis from the governments that support them. *See Payloads for Profit*, *supra* note 36, at 3084; *Soviets Will Offer Space Launch Insurance at Competitive Prices*, AVIATION WEEK & SPACE TECH., Sept. 28, 1987, at 138. Some type of liability limitation scheme, analogous to those benefiting the shipping industry, *see* G. GILMORE & C. BLACK, THE LAW OF ADMIRALTY 818-957 (2d 1975), and the aviation industry under the Warsaw Convention, or perhaps a government role as insurer, may be needed to remedy this problem. *See generally* Doherty, *Insurance, Risk Sharing and Incentives for Commercial Use of Space*, in ECONOMICS AND TECHNOLOGY IN U.S. SPACE POLICY, *supra* note 87, at 81. Less attention has been paid to tax issues, but it is arguable that space, as an underdeveloped area, should be given special tax treatment—an approach adopted, for example, to encourage businesses to locate in Puerto Rico. *See* Internal Revenue Code § 936 (Tax credits for investment in Puerto Rico and Caribbean Basin countries).

the patent treatment of inventions first reduced to practice in space,[112] should be reviewed and the law changed wherever possible to ensure that the launch industry and its customers do not encounter inadvertent or unnecessary roadblocks. The key, in these areas not directly related to active encouragement of the industry, is for the government to recognize that a flourishing launch industry is a national priority and should be treated as such in general. Just as with the railroads, the emphasis should be on encouraging, wherever possible, the development and expansion of an industry that may be a vital part of the infrastructure of tomorrow.

VII. CONCLUSION

If the United States is to remain a world leader in technology and economic growth, it must ensure that it remains a leader in those industries that, like the railroads of the last century, are crucial as technology drivers[113] and as sources of new industries[114]—in short, in strategic industries. One such industry, as we have argued above, is the commercial launch industry. In order to ensure that the United States remains a major competitor in that field, where the presence of foreign competition is growing steadily, the United States must be home to companies that can provide launch services profitably and at a competitive price.

This cannot be done by continuing to rely on launch technology that is, for the most part, thirty years old.[115] In order to develop the new, lower-cost technology needed to remain competitive, the United States must undertake the kind of aggressive program in support of the launch industry that it has traditionally maintained in support of the aviation industry. This means support for research and development aimed at commercial technologies and an adjustment of government procurement and other policies so as to aid the prospects of the industry.

It is, of course, easy enough to remain complacent for the present. Despite the competitive successes of the Ariane system, and the impending presence of the Japanese and other new launch industries, the U.S. industry is doing rea-

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[112]H.R. 2725, 99th Cong., 1st Sess. (1985); H.R. 4316, 99th Cong., 2d Sess. (1986) (Patents in Space Bill); H.R. Rep. 99-788, Part I, 99th Cong., 2d Sess. (1986). *See also Patents in Space: Hearings Before the Subcomm. on Courts, Civil Liberties and the Administration of Justice of the House Comm. on the Judiciary*, 99th Cong., 1st Sess. (1985).

[113]Railroads, though not advancing rapidly themselves in basic technology, fed advances in steam and turbine technology, in metallurgy, and (perhaps most importantly) in management methods. *See* A. CHANDLER, *supra* note 76, esp. at 81-121, 245, 259-72, 188-89. *See generally* W. LANDES, PROMETHEUS UNBOUND: TECHNOLOGY AND ECONOMIC DEVELOPMENT 1750-1900 (1977) esp. at 153-54.

[114]The growth of Western agriculture and minerals extraction, the rise of mail order businesses like Sears and Montgomery Ward, the development of modern commodities markets, and the rapid expansion of telegraphy were all linked to the growth of railroads. *See* A. CHANDLER, *supra* note 76, esp. at 207-39.

[115]*See supra* notes 31-33.

sonably well for now, and probably will continue to do so for some time. Given the long lead times required to introduce new launch technologies, however, by the time the U.S. industry is in visible trouble it will be too late.

Those who believe that there is no threat from foreign competition in the launch field should remember that we have underestimated nearly every foreign threat: who, after all, would have given serious consideration in 1980 to predictions that before the decade was out the U.S. would be inundated by a flood of cheap Korean computers? Foreign countries, even those considered underdeveloped and backward, have caught the United States and its industries napping before. Let us not let it happen again in a field that will likely be as crucial to prosperity in the next century as aviation has been in this one, and railroads were in the last.