

The Railroads and the Space Program Revisited: Historical Analogues and the Stimulation of Commercial Space Operations

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Abstract:

In 1965 historian Bruce Mazlish edited the NASA-sponsored study, *The Railroad and the Space Program. An Exploration in Historical Analogy* (MIT Press), seeking to understand the historical record of government stimulation of private sector investment in infrastructure for the public good. The study team explored several specific episodes of American railroad history. It took as its mission: “In all of these studies an effort will be made to move from the impact of the railroad in the specific area under consideration to an analogy with the possible space impact today in similar areas.” While the result was disappointing at the time there remain lessons to be gained in exploring the historical analogue of railroad building and operation in the nineteenth century and their application to an expansion of space exploitation. While many are familiar with the enticing of American transcontinental railroad construction through land grants, national, state, and local governments had engaged in a range other stimulative efforts to facilitate railroad development. These included tax breaks, investment credits, and otherwise favorable decisions supporting these business interests. It also involved in some instances direct subsidies for a time, monopolies not only on railroad operations but also in ancillary and even tertiary industries, and changes to regulations to ease requirements for labor, safety, and other factors. This paper revisits this analogue, drawing several key findings from the railroad experience. It suggests that there is a broad range of options that have been pursued in the past to stimulate investment in infrastructure—in this case in railroads—that have application for future space operations. Not all of these options were successful—some failed outright and others had detrimental unintended consequences—and that will be discussed as well.

Introduction:

Everyone uses historical analogies to understand current issues and to help make decisions about present-day concerns. Sometimes they use those analogies effectively, and sometimes not. The current debate over national economic policy is rife with historical analogies and sometimes even the same analogues are deployed to support differing positions. There is a long history of the use and abuse of analogs, offering perspectives on how they might be effectively employed in analysis of current challenges.¹

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¹ This article is drawn from Roger D. Launius, “Historical Analogs for the Stimulation of Space Commerce,” a research report completed in fulfillment of NASA contract NNX12AN66G, submitted December 31, 2013.

in the specific area under consideration to an analogy with the possible space impact today in similar areas.”² While the result was disappointing at the time there remain lessons to be gained in exploring the historical analogue of railroad building and operation in the nineteenth century and their application to an expansion of space exploitation. While many are familiar with the federal government’s enticing of American transcontinental railroad construction through land grants, there were many other stimulative efforts to facilitate railroad development.

This essay revisits this analog, drawing several key findings from the railroad experience. It suggests that there is a broad range of options that have been pursued in the past to stimulate investment in infrastructure—in this case in railroads—that have application for future space operations. The government offered the following six inducements for private development:

1. Land grants as a means of offering potential future revenue, tied to success in creating the railroad system.
2. Direct government appropriations to the company involved in the endeavor.
3. Waivers/modifications to taxes and other regulatory requirements.
4. Contracts for services once capability is demonstrated.
5. Government endorsement and backing of corporate bonds/assets.
6. Indirect support for related but supplemental elements of the railroad transportation system.

In every case these government initiatives were intended to leverage (and not replace) existing private funding, especially additional industry and venture capital. To those six points use with the railroads, we might add the following:

- Private financing supplemented with government loans.
- Property and patent rights granted to participating firms.
- Broadly construed revenues produced from transportation and other fees.

Regardless, one must ask these critical questions in the context of developing new space transportation structures: “How important, in the final analysis, is cheaper access to space? Is it really the key to future growth of space activities?” This seems to be at the cusp of what will go into any stimulation of private space transportation effort.

The Making of a Classic Historical Study:

In 1965 historian Bruce Mazlish edited the NASA-sponsored study, *The Railroad and the Space Program. An Exploration in Historical Analogy*, a book that has become legendary as a fine analysis of railroading in the nineteenth century with almost no applicability to the space program. Despite that result, the book took as its mission: “In all of these studies an effort will be made to move from the impact of the railroad in the specific area under consideration to an analogy with the possible space impact today in similar areas.”³ The original study offered an

² Bruce Mazlish, ed., *The Railroad and the Space Program. An Exploration in Historical Analogy* (Cambridge, MA: The MIT Press, 1965).

³ Earl P. Steveson, “Report of the CS,” Records of the Academy (American Academy of Arts and Sciences), 1963/1964, pp. 150-51, quoted in Jonathan Coopersmith, “Great (Unfulfilled) Expectations: To Boldly Go Where No Social Scientist Has Gone Before,” in Steven J. Dick, ed., *Remembering the Space Age: Proceedings of the 50th Anniversary Conference* (Washington, DC: NASA SP- 2008-4703, 2008), p. 142.

outstanding overview of early American railroad history and technology, but it failed to present a compelling analog comparable to spaceflight. One of the essayists in the volume, Thomas P. Hughes, offered this insight: “Wherever and whenever nature in her non-animal manifestations frustrates man in the pursuit of his objectives, there exists a technological frontier.” He added that space exploration was a new case because it was a completely new arena of activity: “The most extreme result of technological frontier penetration is the creation of a man-made environment and the rendering of nature imperceptible.”⁴

While the result was disappointing at the time, there remain lessons to be gained in exploring the historical analogue of railroad building and operation in the nineteenth century and their application to an expansion of space exploitation. While many are familiar with the enticing of American transcontinental railroad construction through land grants, that was far from the sum total of assistance. National, state, and local governments engaged in a range of other stimulative efforts to facilitate railroad development. These included tax breaks, investment credits, and otherwise favorable decisions supporting these business interests. It also involved in some instances direct subsidies for a time, monopolies not only on railroad operations but also in ancillary and even tertiary industries, and changes to regulations to ease requirements for labor, safety, and other factors. If there is any one conclusion in this survey, it is that there is a broad range of options that have been pursued in the past to stimulate investment in infrastructure—in this case in railroads—that have application for future space operations.

Fostering Early Railroads in America:

The first issue to be considered in investigating the development of railroads in the United States is the close relationship between the government and transportation industry. This predated the invention of the steam locomotive and the building of railroads but it has been a persistent and impermeable aspect of the subject’s history. Government involvement might be considered positive or negative—it might be viewed as an intrusion on the free enterprise economy or as a help in securing the public welfare—depending on perspective. According to Jeffrey R. Orenstein:

In the transportation field, especially, it started with the earliest road and canal building efforts, continued during the creation of the Interstate Commerce Commission in the nineteenth century, and intensified with the temporary nationalization of railroads during World War I, the government promotions for emerging transportation modes, and the rail quasi-nationalization of the present era. Railroads, particularly, have been major targets of both direct and indirect interventionist public transportation policies for over a century and a half.⁵

⁴ Thomas P. Hughes, “A Technological Frontier: The Railway,” in Bruce Mazlish, ed., *The Railroad and the Space Program. An Exploration in Historical Analogy* (Cambridge, MA: MIT Press, 1965), p. 53.

⁵ Jeffrey R. Orenstein, *United States Railroad Policy: Uncle Sam at the Throttle* (Chicago: Nelson-Hall, 1990), p. 1.

The result of this approach to rail transportation produced both public subsidies and regulation, sometimes alternating between two poles without apparent rationality.⁶ From the very beginning the political economy of railroads entered into a co-dependent relationship with government. When held in creative tension this could be a positive development, but it has not always maintained that balance.⁷

Prior to the 1830s the U.S. government had waffled back and forth between direct construction of what were euphemistically titled “internal improvements,” especially roads, harbors, and canals. The National Road from the mid-Atlantic seaboard to Illinois—now the route of U.S. highway 40—was a famous example of government investment in national infrastructure. Senator Henry Clay of Kentucky famously championed what he referred to as the “American System” to remake the nation into a modern state and such investments in transportation systems were a direct result. When Andrew Jackson became president after the election of 1828, however, this philosophy met powerful opposition from a White House that believed in individualism and self-reliance. Jackson vetoed the Maysville Road bill on May 27, 1830, which proposed a government subscription of \$150,000 to a company building a 60-mile turnpike in Kentucky. Partly the result of animosity toward Henry Clay, Jackson also described it as “a measure of purely local character...conferring partial instead of general advantages” and therefore not in the general interest of the nation.⁸ But Jackson went further in his farewell address in 1837, announcing that his actions had “finally overthrown...this plan of unconstitutional expenditure for the purpose of corrupt influence.”⁹

That position remained national policy for several decades thereafter, although at the state and local level considerable public money aided such construction projects. In essence, according to historian Carter Goodrich:

The national government might aid transportation in various ways which returned no direct income, but it must refrain from building revenue-producing public works. It was not to construct roads and canals on which tolls were to be collected. It was not to subscribe to the stock of improvement companies. Most certainly, it was not to undertake the burden and responsibility of a scientifically planned system of national improvements.¹⁰

All else, for many Jacksonian Democrats, should be left either to private enterprise or to the will of the local and state governments. It was those local and state authorities that spurred the first investment in railroad construction in the 1830s and 1840s.

⁶ William Thoms, “Nationalization, No; Statelization, Yes,” *Trains Magazine*, April 1985, pp. 44-48; Roy Sampson, Martin Farris, and David Shrock, *Domestic Transportation: Practice, Theory, and Policy* (Boston, MA: Houghton-Mifflin, 1985, 5th ed.).

⁷ Orenstein, *United States Railroad Policy*, p. 22.

⁸ Carter Goodrich, *Government Promotion of American Canals and Railroads* (New York: Columbia University Press, 1960), pp. 40-42.

⁹ “Farewell Address of Andrew Jackson,” in Joseph L. Blau, ed., *Social Theories of Jacksonian Democracy* (New York: Hafner, 1947), p. 305.

¹⁰ Goodrich, *Government Promotion of American Canals and Railroads*, p. 43.

The first railways in the United States emerged from a succession of experiments undertaken by dreamers and visionaries in the first part of the nineteenth century. They emphasized private sector investment and free market capitalism, but also predatory operations.¹¹ Although a private enterprise, and the investors guarded their prerogatives on that score, there was always a significant public investment. As one scholar concluded: “Opposition of vested interests such as canals, and even farmers, and the difficulties of raising venture capital, on the one hand, coupled with the desire of many localities for improved transportation, on the other, led a number of states to embark upon railroad construction.”¹²

The first railroad to use a steam engine, the South Carolina Canal and Rail Road Company, was chartered December 19, 1827, and began operations in downtown Charleston in February 1829 for hauling cotton bales. On April 1, 1830, a mile of double tracked railroad entered into operation, and within three years it had been extended to Hamburg, South Carolina, a distance of 136 miles from Charleston.¹³ Investors in the railway saw an immediate market, bringing cotton from mid-state plantations to Charleston for shipment to textile makers elsewhere. Even so, they were unable to compete in the free market with canals already providing this service. Accordingly, they sought and received support from the state to ensure solvency. This took a variety of forms: (1) direct South Carolina appropriations to the company making the state an investor in the Railway, (2) waivers of a portion of the state’s tariff on exports, (3) contracts to carry the state’s mail, (4) state endorsement and backing of corporate bonds which ensured they could be sold for face value, and (5) U.S. government indirect support for surveying and laying out the railroad because of its use as a transportation means for military purposes.¹⁴ Even so, debt and bankruptcy forced the original railroad company to reorganize and restructure in the 1840s. As one scholar concluded: “Some of the aid was in the form of a tariff reduction on iron, of banking privileges, of tax abatements, of grants of parcels of land by right of way, and of construction. State and local aid was more generally in stock subscription, donation of state bonds, loans, and endorsement of railroad bonds.”¹⁵

The boom in railroad construction throughout the United States took place during the remainder of the antebellum period, also with considerable government stimulation of the industry. This

¹¹ Robert Sobel, *The Fallen Colossus* (New York: Weybright and Talley, 1977), chapters 1 and 5; J. Daughen and P. Benzen, *The Wreck of Penn Central* (Boston, MA: Little, Brown, 1971); Richard Saunders, *The Railroad Mergers and the Coming of Conrail* (Westport, CT: Greenwood Press, 1978).

¹² Dudley F. Pegrum, *Transportation: Economics and Public Policy* (Homewood, IL: Richard D. Irwin, Inc., 1963), p. 52.

¹³ Association of American Railroads, *American Railroads: Their Growth and Development* (Washington, DC: Association of American Railroads, 1956), pp. 5-6; Pegrum, *Transportation*, pp. 51-52; Samuel M. Derrick, *Centennial History of South Carolina Railroad* (Columbia, SC: State Publishing Company, 1933).

¹⁴ Ulrich Bonnell Phillips, *A History of Transportation in the Eastern Cotton Belt to 1860* (New York: Columbia University Press, 1908), pp. 132-220.

¹⁵ Kent T. Healy, *The Economics of Transportation in America: The Dynamic Forces in Development, Organization, Functioning and Regulation* (New York: Ronald Press Company, 1940), p. 105.

took the form of state and local tax relief, project endorsement, public investment, and outright granting of subsidies. During the period before the Civil War the states of Illinois, Pennsylvania, Indiana, Michigan, Virginia, and Georgia all built as public works railroads. In other states—notably Massachusetts, North Carolina, and Missouri—railroads became public commodities when the state took ownership of bankrupt lines. Most of these turned out poorly and the states divested themselves of ownership by the time of the Civil War.¹⁶

Local governments also directly supported railroad construction, especially when the Panic of 1837 sucked considerable investment capital out of the financial system. A good case study of this direct support may be found in the rivalry of Troy and Albany, New York, who both wanted control of shipment between New York and the Midwest. The Erie Canal of twenty years earlier had been a boon to Albany, but Troy sponsored the building of the Schenectady and Troy Railroad at a cost of \$700,000. Completed in 1842 the city operated it as a municipal activity and began to gain market share from the Erie Canal. Not to be outdone, the city fathers in Albany supported construction of the Mohawk and Hudson Line with a \$250,000 investment. Neither proved successful over the long run and both were acquired by the New York Central Railroad in the 1850s. Overall, more than \$1.2 million—some \$5 billion in 2010 dollars—were invested in railroads by local and state governments in New York between 1837 and 1860.¹⁷

Increasingly as the century progressed the federal government also scratched the railroad building itch. This came largely because of the rising realization that a transcontinental railroad would become necessary in the coming decades. In most instances government investment took the form of direct land grants to railroad companies. The first of these came when the U.S. government granted land to the state of Illinois in 1850 and it, in turn, granted it to the Illinois Central Railroad. This came as a result of the Land Grant Act of 1850, which provided 3.75 million acres of land to the states to support railroad projects. By 1857, 21 million acres of public lands had been transferred to railroads in the Mississippi River valley. Government land grants quickly followed along the same lines to the states of Mississippi and Alabama.¹⁸ Regardless of these government investments, many of the efforts went bankrupt. “The belief that the mere presence of the Illinois Central would bring prosperity to the state, or that the railroad would actively bring it about,” historian Robert L. Brandfon concluded, “was an illusion.”¹⁹

This legislation pioneered a standard approach that the federal government followed thereafter: alternate even-numbered sections of six miles on either side of the proposed railways that the company could develop and sell. Since the land had not been attractive because of a lack of transportation—it had been available for sale to anyone for years at \$1.25 per acre—the railroad now found a ready market for land useful to farmers. They were able to raise the price per acre to

¹⁶ Pegrum, *Transportation*, p. 54.

¹⁷ Harry H. Pierce, *Railroads of New York: A Study of Government Aid, 1826-1875* (Cambridge, MA: Harvard University Press, 1953), pp. 116-18, 178-92; Goodrich, *Government Promotion of American Canals and Railroads*, p. 58-62.

¹⁸ K. Austin Kerr, “Railroad Policy,” in Julian E. Zelizer, ed., *The American Congress: The Building of Democracy* (New York: Houghton Mifflin, 2004), p. 288.

¹⁹ Robert L. Brandfon, “Political Impact: A Case Study of a Railroad Monopoly in Mississippi,” in Mazlish, *The Railroad and the Space Program*, p. 186.

\$2.50 and still find buyers. By the 1950s about 8 percent of all railroad mileage in the U.S. had been constructed using money secured from federal land grants; some 131 million acres of public lands had been turned over to railroad companies for private use through this system.²⁰

Building the Transcontinental Railways:

These efforts were nothing in comparison to the railroad construction that took place during the Gilded Age. Congress modified its approach for land grants with the Pacific Railroad Act of 1862 because of the very present need to build a transcontinental railroad. In this effort lawmakers resolved to “do enough, and only enough, to induce capitalists to build the Pacific railway.” Signed into law by President Abraham Lincoln on July 1, 1862, this act authorized extensive grants of public land along the right of ways and the issuance of 30-year government bonds at 6 percent. These subsidies went directly to the Union Pacific Railroad and Central Pacific Railroad to support construction of a continuous transcontinental railroad from Council Bluffs, Iowa to Sacramento, California.²¹

The act’s most famous provisions dealt with the land grants. Section 2 provided each company contiguous rights of way for their rail lines as well as all public lands within 200 feet on either side of the track. Section 3 granted an additional 10 square miles of public land for every mile of track laid except when running through cities or across rivers. It allocated this land as “five alternate sections per mile on each side of said railroad, on the line thereof, and within the limits of ten miles on each side.” This turned out to be a most lucrative transfer of public property to the private sector, giving the favored companies a total of 6,400 square acres for each mile of track. By the time of the completion of the first transcontinental line in 1869, something approaching 175 million acres of public land had been transferred to the Union Pacific and the Central Pacific.²² The central provisions included:

- Granted 20 sections of land for every mile of completed railway.
- Railroads used value of land as collateral for private loans.
- Provided subsidy bonds, essentially a second mortgage, to lend funds to railroad firms.
- Loans repaid largely by transportation revenues and land sales.
- Government received non-monetary benefits (troop transport cost reductions).
- Increased returns by some 2 percent.

Throughout this process the Union Pacific undertook construction westward from a point near Omaha, Nebraska; the Central Pacific headed eastward from Sacramento, California. The meeting point of the two lines on May 10, 1869, proved memorable. Collis P. Huntington of the

²⁰ Association of American Railroads, *American Railroads*, pp. 7-13.

²¹ “An Act to aid in the construction of a railroad and telegraph line from the Missouri river to the Pacific ocean, and to secure to the government the use of the same for postal, military, and other purposes,” 12 Stat. 489, July 1, 1862, available on-line at http://www.cpr.org/Museum/Pacific_Railroad_Acts.html, accessed 8/29/2013 2:14 PM.

²² Ibid.

Central Pacific and Grenville Dodge of the Union Pacific linked the tracks at Promontory Summit (also known as Promontory Point), Utah.²³

Railroad expansion provided new avenues of immigration into the Great Plains and Rocky Mountain West. The railroads made money doubly by transporting people, goods, and commodities for a price, and by selling portions of their land to arriving settlers at a handsome profit. Lands closest to the tracks, of course, drew the highest prices.

The national government also levied requirements on the transcontinentals. Those receiving federal assistance were required to transport U.S. mail, troops, and property at reduced rates. A mail discount rate of 20 percent and a 50 percent reduction in all other government transportation fees served national interests. This arrangement only ended with congressional action in 1940. Dudley F. Pegrum concluded about this development:

Public aid to railroad development resulted in a very rapid expansion of the railroad network, which probably assisted in opening up the country more rapidly than would have been the case otherwise. At the same time it gave rise to abuses that were to have serious repercussions later on. The inevitable overbuilding and the extensive duplication of competitive lines created excess capacity that resulted in unsatisfactory earnings and financial failures that still plague the industry. Financial abuses flourished under public aid and the totally inadequate standards of financial responsibility of the period.²⁴

Without the assistance of the U.S. government, railroad construction between 1860 and 1900 would certainly have proceeded at a less aggressive pace. At the end of the Civil War only 45,000 miles of track had been laid. Between 1871 and 1900, another 170,000 miles were added to the nation's railroad system. Much, but not all, of this growth came as a result of the efforts to construct transcontinental railroads.²⁵ The investment of large start-up costs—track surveying and construction, rolling stock acquisition, support and logistics systems established, all before any revenue could accrue—meant that both private banks and entrepreneurs shied away from investment. Government investment, largely but not entirely through land grants, contributed to the success of four out of the five transcontinental railroads that were built in the period between the Civil War and 1900. “The total aid in monetary terms of private citizens and local, state, and federal governments was estimated by the Federal Coordinator of Transportation to have

²³ Bruce Clement Cooper, *Riding the Transcontinental Rails: Overland Travel on the Pacific Railroad 1865-1881* (Philadelphia: Polyglot Press, 2005): pp. 1-15.

²⁴ Pegrum, *Transportation*, p. 57.

²⁵ George Rogers Taylor, *The Transportation Revolution, 1815-1860* (New York: Holt, Rinehart, and Winston, 1951); John F. Stover, *The Railroads of the South, 1865-1900: A Study in Finance and Control* (Chapel Hill: University of North Carolina Press, 1955); John F. Stover, *American Railroads* (Chicago: University of Chicago Press, 1961); Robert W. Fogel, *The Union Pacific Railroad: A Case in Premature Enterprise* (Baltimore, MD: Johns Hopkins University Press, 1960); Carter Goodrich, *Government Promotion of American Canals and Railroads, 1800-1890* (New York: Columbia University Press, 1960); Alfred Dupont Chandler, *Henry Varnum Poor: Business Editor, Analyst, and Reformer* (Cambridge, MA: Harvard University Press, 1956); Alfred Dupont Chandler, *The Railroads, The Nation's First Big Business: Sources and Readings* (New York: Arno Press, 1965).

amounted to \$1.4 billion,” as reported by Dudley Pegrum.²⁶ In 2013 dollars that would amount to more than \$45 billion.

There is more relevance to this story for spaceflight than might be immediately apparent. The direct comparison of the public/private partnership that created the transcontinental railroads is the potential for government stimulation of the launch industry. The challenge is technological in the sense that new launchers are necessary for efficient operations, just as the laying of track and the acquisition and operation of rolling stock was critical to the transcontinental carriers of the nineteenth century. The similarities include the high start-up costs associated with new, more efficient launchers, the highly-regulated operational environment, and the high risk/high return potential of the endeavor. The question before policy-makers, like the Congress of 1862, is how best to “do enough, and only enough, to induce capitalists to build” new space transportation systems.

In the railroad example the forms of support included:

1. Land grants as a means of offering potential future revenue, tied to success in creating the railroad system.
2. Direct government appropriations to the company involved in the endeavor.
3. Waivers/modifications to taxes and other regulatory requirements.
4. Contracts for services once capability is demonstrated.
5. Government endorsement and backing of corporate bonds/assets.
6. Indirect support for related but supplemental elements of the railroad transportation system.²⁷

In every case these government initiatives were intended to leverage (and not replace) existing private funding, especially additional industry and venture capital.

There are those that believe the federal government has been responsible for the stagnation present in fifty years of rocket technology. No question, after half a century access to space remains a difficult challenge. The technical challenge of reaching space with chemical rockets—particularly the high costs associated with space launch, the long lead times necessary for scheduling flights, and the modest reliability of rockets—has demonstrated the slowest rate of improvement of all space technologies. All space professionals share a responsibility for addressing these critical technical problems. The overwhelming influence that space access has on all aspects of civil, commercial, and military space efforts indicate that it should enjoy a top priority for the twenty-first century.²⁸

²⁶ Pegrum, *Transportation*, pp. 439-40.

²⁷ Phillips, *A History of Transportation in the Eastern Cotton Belt to 1860*, pp. 132-220.

²⁸ More than 1,000 space access studies have reached this conclusion over the last 40 years. See Roger D. Launius and Howard E. McCurdy, *Space Exploration in the Twenty-first Century: NASA and Beyond* (San Francisco: Chronicle Books, 2001 forthcoming), chapter 4; United States Congress, Office of Technology Assessment, *Launch Options for the Future: Special Report* (Washington, DC: Government Printing Office, 1984); Vice President’s Space Policy Advisory Board, “The Future of U.S. Space Launch Capability,” Task Group Report, November 1992, NASA Historical Reference Collection, NASA History Office, Washington, DC; NASA Office of Space Systems Development, *Access to Space Study: Summary Report* (Washington, DC:

Applying this Analogy to Space Access:

Of course, a key element in the spacefaring vision long held in the United States is the belief that inexpensive, reliable, safe, and easy space flight is attainable. Indeed, from virtually the beginning of the twentieth century, those interested in the human exploration of space have viewed as central to that endeavor the development of vehicles for flight that travel easily to and from Earth orbit. The more technically-minded recognized that once humans had achieved Earth orbit about 200 miles up, the vast majority of the atmosphere and the gravity well had been conquered and that humanity was then about halfway to anywhere else they might want to go.²⁹

A central element in solving the current space access problem is to stimulate private sector innovation—accomplished through public/private partnerships—to develop new, safe, reliable, and inexpensive rockets. But this will not happen alone. The private sector cannot solve all problems as if by magic. At the same time, the U.S. government must relax its restrictions on the transfer of rocket technology to foster private sector space launch innovation across national boundaries. That is an exceptionally tall order, since space is overrun with dual-use technology that is critical to national security. The problem here, as John Krige has noted, is that “collaboration has worked most smoothly when the science or technology concerned is not of direct strategic (used here to mean commercial or military) importance.” He added that as soon as a government feels that its national interests are directly involved in a field of R&D, it would prefer to protect these capabilities from proliferation. He also noted that the success of cooperative projects may take as their central characteristic that they have “no practical application in at least the short to medium term.”³⁰

In the end, the key points noted above concerning government involvement in nineteenth century railroad development remain valid to some degree or another with the exception of land grants: there are none to offer in orbital space. However, there is the related right to access government assets in space—especially the International Space Station—and allowing a portion of it to be accessed by companies developing effective space transportation systems.

One of the central tenets of the new space community is that modern advances in technology and materials will allow inexpensive access to low-Earth orbit (LEO). Unfortunately, this has not come to pass as yet. Current technological, economic, and regulatory realities combine to prohibit payload delivery to LEO for less than \$1,000 per pound without significant changes to the current policy arena. Moreover, and this may be the core challenge for the future, no one has yet documented a clear, solid business model that would lead to a privately-funded and operated space transportation system. Government customers are the major users of space transportation, not settlers on the American frontier homesteading land near the railroad. A market that could

NASA Report, 1994).

²⁹ This is the premise of G. Harry Stine, *Halfway to Anywhere: Achieving America's Destiny in Space* (New York: M. Evans and Co., 1996), a book that explores the historical path of launch vehicle development in the United States.

³⁰ John Krige, “The Politics of European Collaboration in Space,” *Space Times: Magazine of the American Astronautical Society* 36 (September-October 1997): 4-9.

support the costs of creating such vehicles still seems far removed from the realities before the United States in the near term.

Regardless, government investment has been significant to the present and there may be some expansion in the future with continued adherence to the following:

1. Government granting of use of publicly owned assets in low-Earth orbit, especially the International Space Station.
2. Direct government appropriations to the companies building space hardware, such as an expanded CCDev-type program.
3. Waivers/modifications to taxes and other regulatory requirements.
4. Contracts for services once capability is demonstrated.
5. Government endorsement and backing of corporate bonds/assets.
6. Indirect support for related but supplemental elements such as range management, indemnification, and ITAR.
7. Technological knowledge transferred from government research organizations to private sector firms developing revolutionary launch capabilities.

Beyond low-Earth orbit, especially in terms of a lunar transportation capability, might the government foster private sector development through the creation of such a system? The question to ponder: Is a privately developed lunar transportation corridor possible? The experience of the railroad suggests that it might be privately financed, although it would still need to be supplemented with government loans/bonds or other means of limiting private risk. Revenues produced from transportation fees could become a boon to the companies, just as they were for the transcontinental railroads of the nineteenth century. Property and patent rights could be granted to participating firms. There are, of course, challenges to this approach. Fundamental would be an overturning of the Outer Space Treaty of 1967 and the Moon Treaty—the latter of which the U.S. is not a signatory—since there are no possibilities of lunar land grants in the current international treaty system. There might be opportunities short of outright ownership that would allow for the right to use land and extract minerals. Moreover, there might be a delta between the costs to be incurred and the value of future patents, thereby limiting large investments. Regardless, there are applicable ideas from the railroad experience that might be pursued.

Is this an Analogy Useful for Spaceflight?

With this as the case, are there lessons from the past that might be applied to future public/private partnerships in space? In the context of these historic examples of the railroading public private partnerships the most applicable to space activities are in transportation and I will concentrate my comments on this arena. Public/private partnerships in the development of American transportation systems has been varied, often complex, and over time remarkably boutique. Transportation partnerships have gradually evolved, taken a divergent set of paths, and ranged from fully public to fully private and virtually everything in between. Only one conclusion may be reached concerning the development of these railroads—whether the initial transportation mode began as a private or a public initiative—all successful railroads have incorporated a mixed model of funding and operations.

Initial railways development began as a private enterprise, but the costs of investment were too great to be sustained. This led to the entrance of the government—sometimes local, often state, and in the latter nineteenth century federal—to underwrite the cost of investment in a variety of inventive ways ranging from direct ownership to land grants, regulatory reforms, tariff splits, bond sales, and the like. Regardless of the public investment, private enterprise tended to dominate the public/private partnership. By the latter nineteenth century rail systems had grown so critical to American economic expansion, national security, and migration that the federal government intervened to assert greater regulatory power over this partnership, regulating services and costs, standardizing systems, and enforcing safety. Most important, it never asserted ownership—in contrast to other models in other nations—except in times of war.

Beyond this, for the U.S. to promote space commercialization, it must make industry aware of the spatial conditions in which flight will take place. Spaceflight is already a risky business but it is increasingly becoming more so with more and more devices flying over the Earth in as many flight paths. I recommend the federal government begin to think about space debris and their corresponding flight paths to ensure greater safety in space.³¹ International organizations and national space organizations also should begin to think about regulating space as an environment prone to pollution and find a way to restrict which types of satellites should be orbited. Alternatively, the international community could develop a set of standards for satellites such as satellite durability and lifetime. This type of agreement will face harsh resistance but may well be necessary should orbital accidents begin to take place as we as humans overpopulate our skies with satellites. By avoiding accidents not only during takeoff and landings but also during flight, space commercialization has a greater chance for success.

³¹ David Whitlock, “History of On-Orbit Satellite Fragmentations,” NASA Johnson Space Center, 2004, available on-line at www.orbitaldebris.jsc.nasa.gov/library/SatelliteFragHistory/-13thEditionofBreakupBook.pdf, accessed 11/11/2013 5:47 PM.