The railroad and the space program

The construction of the U.S. railroads in the 19th century was an "Apollo project," fostering the development of the nation. By Marsha Freeman.

On May 25, 1961, President John F. Kennedy announced that within a decade, the United States was going to land a man on the Moon, and return him safely to the Earth. Until then, the U.S. space program had been proceeding at a rather leisurely pace, as the Eisenhower administration refused to have itself seen as being in a "race" with the Soviet Union.

But President Kennedy knew that a national commitment to this great endeavor would accomplish something more important than reestablishing American prestige. The task would require the mobilization of the best of the nation in science, industry, technology, and education. The country would be changed, perhaps permanently, in meeting the challenge to do what had never been attempted before.

Even before the President's announcement, British anti-technology cynics, pseudo-religious figures, psychological-warfare think-tanks, and sociologists, objected that the Apollo program could have a "damaging" effect on the U.S. population.

Pressure was put on the National Aeronautics and Space Administration (NASA) to give grants to sociologists for studies on how to blunt the unbridled optimism and economic opportunity the space program promised to provide, not to mention the wonder of the entire endeavor, and its impact on young children. On March 24, 1961, the House Committee on Science and Astronautics released a report prepared for NASA by the Brookings Institution, proposing studies on the "implications of peaceful space activities for human affairs."

Three grants for such studies were awarded by NASA in 1962 and were overseen by the American Academy of Arts and Sciences in Boston.

One study was published as a book, *Social Indicators,* in 1965. It was reportedly the brainchild of Bertram Gross, later editor of the London Tavistock Institute's psychological-warfare journal, *Human Affairs*. In his preface, Gross lauds President Johnson's Great Society program, which he describes as "responsive to the new political situation created by the transformation of an advanced industrial society into the world's first example of 'postindustrialism.' " But, Gross complains, President Johnson is still relying on "concepts and data that have decreasing relevance to the new national goals," such as economic growth, and "we find practically no information whatsoever on 'social structures.' "

In the foreword, Earl P. Stevenson, chairman of the Committee on Space for the Academy, states that "such measures of social performance are all the more important in a 'postindustrial' society, one in which the satisfaction of human interests and values has at least as high a priority as the pursuit of economic goals. The development of a system of social indicators and accounting is a subject of real interest to the Johnson administration."

The author of *Social Indicators,* Raymond Bauer, professor of business administration at Harvard, states straightforwardly the reason for his book: "In the conduct of human affairs, our actions inevitably have second-order consequences. These consequences are, in many instances, more important than our original action." One example he cites is the use of pesticides which kill insects, but have the second-order effect of killing birds (repeating the lies later decreed into law to ban DDT).

Another study carried out under the NASA contract was by Robert N. Rapaport, and was to be titled, "Social Change: Space Impact on Communities and Social Groups." This study was never published, however; perhaps because of the outrageousness of its reported conclusion, that the greatest danger of the space program would be the unbridled optimism that would lead "every man, woman, and dog" to want to be a scientist.

But in the report that follows, we examine the first study that was published under the NASA contract—a study that proceeds from quite a different premise than the two just mentioned. This was *The Railroad and the Space Program: An Exploration in Historical Analogy,* edited by Bruce Mazlish and published by MIT Press in 1965. In looking for an analogy to the impact the space program would have on the nation, Mazlish appropriately chose the 19th-century equivalent of the Apollo program: the building of the American railroads.

Mazlish writes that the approach of the book is to "study the impact of a social invention analogous to that of the space program." Such an analogous invention should be "in part, technological, . . . which is economic in its effect, involving such things as the large-scale employment of manpower, the wide-spread use of materials, and extended, important financial ramifications; which is also political, in the sense of having legislation surrounding its use. . . . The social invention I

Apollo 11 astronauts in a motorcade through the streets of Madrid, Spain, Oct. 7, 1969. The space program, like the railroad-building endeavor of the last century, was an inspiration to young and old, the world over.

recommend is the coming of the railroad."

Mazlish says that the boldness of the aims of the new space program can be justified "by the reflection that, though it is true that 'Fools rush in where angels fear to tread,' man has now been foolish enough to rush in where angels used to fly."

Opposition to technology, then and now

The first chapter of the book discusses some of the historical analogues of the space program to the building of the railroads, including the role of the nay-sayers.

Mazlish notes that the British magazine *Quarterly Review* commented in 1825: "Can anything be more palpably ridiculous than the prospect held out of locomotives travelling twice as fast as stage coaches? We should sooner expect the people of Woolwich to suffer themselves to be fired off upon one of Congreve's Rockets as trust themselves to the mercy of such a machine going at such a rate."

Sociologist Lewis Mumford, writing in "The Transformation of Man," published in 1956, had a similar view: "Under such conditions, life would again narrow down to the physiological functions of breathing, eating, and excretion. . . . By comparison, the Egyptian cult of the dead was overflowing with vitality; from a mummy in his tomb one can still gather more of the attributes of a full human being than from a spaceman."

And Hannah Arendt, in "Man's Conquest of Space" (1963), commented that the "philosophical impact" of the space program would be that "of making man insignificant."

Some people saw the railroad, along with industrial society in general, as violating God's intentions. "What is the *image* held by religious-minded individuals as to the significance in this area of the space program?" Mazlish asks.

In the early 1960s, the estimate was that each dollar of funding for the space program would produce $2 of economic activity. But this was really just a guess. A decade later, necessarily incomplete studies of the economic impact of the government funding for the Apollo program would estimate that at least $10 of economic activity was produced for each dollar spent.

How does this compare with the way the nation was transformed by the coming of the railroads?

The railway: driving new industries

In the second chapter of the book, Thomas Parkes Hughes states a general dictum: "Wherever and whenever nature in her nominal manifestations frustrates man in the pursuit of his objectives, there exists a technological frontier." Hughes goes on to observe: "The economic and political factors influencing technological decisions in less advanced America contrasted with those in Britain. The engineers surveying a route for the Baltimore & Ohio Railroad in 1828 acted on the assumption that the nation's political economy created an unlimited and immediate need for railways in America. . . . These sentiments were reinforced by the politically minded who considered railways and canals as ties binding the new nation."

In the 1820s, the emphasis was on the *railway* element of the system, not the motive power. Before the railroad, "internal navigation was limited to those areas where water ran naturally or could be channeled artifically; and to those waterways where frosts were not severe and prolonged. . . . For example, a major disadvantage of the Erie Canal—extending as it did from the lake to the navigable Hudson at Albany—was the freeze-up for four or five months during a hard winter. . . . The railway engineers transcended these natural limitations by substituting a 'way' of rails for the contingent-upon-nature waterway."

The massive project to join up the nation by rail led to the development of entirely new industries, and pushed forward fledgling manufactures, by creating a vast market for them. The most prominent was iron, and then steel.

The small iron-making capacity in the *ante bellum* United States created a situation where, during the 1850s, foreign rails represented nearly two-thirds of all rail purchases. The quality was such that 40% of total rail requirements between 1839 and 1869 was for replacement rails. Most replaced rails were scrapped, which led to the development of the technology for rerolling of old rails. By 1849, one-quarter of all domestically produced rails were rerolled from disgarded ones. Therefore, the net addition to pig iron production attributable to rails during 1840-60 was less than 5% of the output of blast furnaces.

After the Civil War, the new Bessemer process radically reduced the cost of producing steel, allowing for great economies of scale. This ushered in a new era, and after 1871, the consumption of steel was dominated by rails. At the peak, rails consumed 87% of steel production, turning it into a mass production industry. Robert William Fogel summarizes the situation in his chapter, stating, "The market for rails was indispensable to the emergence of a modern steel industry in the United States."

Henry Bessemer (1813-98) developed the process of steelmaking named for him. The process sent a blast of air through molten pig iron, greatly reducing the cost of producing steel. William Kelly (1811-88) independently discovered the same process in the United States, and, although the patent for the invention was granted to Kelly, Bessemer turned his steelmaking into a commercial enterprise.

Cheap steel in the mid-19th century had potential marketability for ships, boilers, bridges, buildings, ordnance, armor, springs, wire, forgings, castings, chains, cutlery, and other items. But, during the initial decades following the development of the Bessemer process, 80% of the Bessemer steel ingots went for rails.

Entirely new demands were put on manufacture, as techniques had to be found not only to power the railroad engines, but also to provide the braking to stop them. New materials were also required, to withstand the heat, weight, and speed of the iron horse.

Other industries were affected more indirectly from the growth and spread of the railroads. For example, in the case of the telegraph, the railroads were not a major user, but there was a parallel growth and alliance between the two. Telegraph companies could utilize railroad men "to watch the line, straighten poles, re-set them when down, mend wires, and report to the telegraph company," Fogel explains. This allowed them to reduce maintenance costs. The railroads also helped push forward the postal system, one of the telegraph's competitors, by delivering mail faster.

In his contribution, Thomas C. Cochran reports: "In the early days of the railroad, time was still read from sundials. While such readings altered only slightly over short distances, between cities a few hundred miles east or west of each other, the variation would be several minutes. A railroad junction point, such as Buffalo, would have half a dozen clocks showing the time in other major cities such as Albany, Cleveland, Detroit, or Chicago.

"The railroad came to control time, first, by making the station clock the criterion for each town, and second, by establishing four time zones covering all of the United States. The latter change was the result of a decade of timetable conventions, and the ultimate agreement of 1883 superseded 54 regional times represented on railroad schedules."

Reshaping the land and the people

While it is obvious that the coming of the railroads made possible large-scale westward expansion, Thomas C. Cochran relates in *The Railroad and the Space Program* that the new transportation system changed the country's demographics in other ways as well. "The railroads sought to stimulate immigration in order to supply labor for their own construction needs, and to provide farmers and other businessmen for the development of the areas the companies served.

"The railroads advertised for workers in Europe and in the eastern ports, and provided cheap transportation from the coast. The Castle Garden Labor Bureau, supervised by the State of New York, was probably the chief mid-century source of immigrant labor for the railroads. The *Railroad Gazette* noted in 1883, the peak year of immigration up to that time and also a peak year in railroad building, that 'unless the rate of immigration continued high, construction would be handicapped.'

"By 1900 the pattern of what would now be called metropolitan areas was, in its new parts, a creation of the railroad. Chicago, the greatest of the cities built by the railroad, grew from 30,000 people in 1850 to 1,100,000 in 1890."

In his contribution to the book, Robert William Fogel states that, from an economic point of view, the central feature of the railroad was its impact on the cost of inland transportation. Following from the savings in transportation cost, most important was the change in availability of resources. The railroad "increased the *economic accessibility* of various parts of natural endowment of the United States."

One of the most interesting effects of the railroads was their impact on agriculture. By 1840, using natural waterways and canals, 40% of the nation's people lived west of New York, Pennsylvania, and the coastal states of the South. But without rails, studies have shown, economic growth might have been slower, because shipping rates would have been higher due to the higher cost of wagon transport to get to the ship, compared to the cost of rail to the ship. Higher transport costs would have led to the most intensive, rather than extensive, development of agriculture. Without railroads, the "feasible commercial agricultural boundary" would be limited to an average of 40 miles from the navigable waterway.

Fogel shows that shipping agricultural goods would have cost twice as much by water (which in northern climes is not possible for five months of the year), and that, therefore, the great bulk of such commodities was actually sent east by rail. Railroads greatly reduced the amount (and cost) of expensive wagon haulage.

The coming of the railroads had a profound impact on education, as well. Cochran reports, "The railroad was probably a major factor in developing higher education in engineering. At the time that Rensselaer Polytechnic Institute was founded in 1824, the Military Academy at West Point was the only college offering advanced technical studies. The founder of the Institute, Stephen van Rensselaer, thought that training in chemistry for use in agriculture would be the school's chief function, but the demand for engineers to build bridges and railroads soon moved the curriculum in that direction."

By 1835, schools like Rensselaer had civil engineering curricula, which included study of geodesy (leveling, topographical surveying, road surveying), road engineering (common roads, railroads, canals, tunnels), topographical drawing (plans, profiles, and sections of railroad surveys), construction, and the mechanics of solids (friction, strength of materials).

While population grew rapidly in Midwestern industrial cities, thanks to the railroads, Cochran notes, the impact on the rural population was even more dramatic. "The railroad raised the levels of expectation in relation to material success in many communities, and altered both geographic and cultural horizons. . . . Railroads brought city newspapers to rural towns with advertisements of bargains in clothes and home fittings, and of amusements not thought of before by country people. Now on a Saturday, the farm family could take a one-day cheap excursion trip to the biggest nearby city and live for four or five hours in a new world."

Not that this new potential did not have its run-ins with the less broad-minded. Cochran reports that the school board of Lancaster, Ohio "forbade the use of the schoolhouse for a meeting to promote a railroad on the basis that 'such things as railroads and telegraphs are impossibilities and rank infidelity. . . . If God had intended that His creatures travel at the frightful speed of fifteen miles an hour by steam He would clearly have foretold it through His holy prophets.' "

Generations of transport engineers

Discussing the impact of the railroad on education, contributor Paul H. Cootner remarks, "The railroads' needs stimulated technical education and a generation of trained engineers, some of whom were themselves easily drawn off into related areas. Schools set up to train engineers did not disappear when the railroads' needs became less pressing, but merely shifted their expertise and facilities into related educational channels."

Hughes documents how the technology of railroads was transferred to solve the next urgent transport challenge, that in the cities. By 1870, more than 50,000 miles of railway had been opened, and engineering capabilities developed over a half century on the inter-urban frontier, would be transposed to the intra-urban realm.

"The wave of engineers who flourished at the turn of the century when the subways and elevateds opened had been educated during the postwar [Civil War] years, when engineering curricula throughout the nation had been strongly influenced by the railway," Hughes reports. By the 1880s, electricity was available and urban congestion was terrible, as cities had been growing very fast. Engineers who had learned their profession in railway construction played leading roles in introducing rapid transit. Hughes cites several examples:

James Laurie (1811-75), the first head of the American Society of Civil Engineers and chief engineer of several railways, including the New Haven, Hartford, and Springfield, proposed an elevated railway for New York City in a paper, "The Relief of Broadway," which was read before the first regular meeting of the Society.

Isaac C. Buckhout (1830-74) was the superintendent of the New York and Harlem Railroad before planning an underground from Grand Central Depot to City Hall, and another in Brooklyn. Later he became a member of the Committee on Rapid Transit.

Samuel Rea (1855-1929), who eventually became president of the Pennsylvania Railroad after beginning as a construction engineer, published a monograph in 1888 on underground railways. In the 1890s he built 1.75 miles of electrified railroad tunnel to bring the B&O Railroad into the heart of Baltimore.

William J. McAlpine (1812-90) served as the chief engineer of several railways, including the Erie, before planning an underground rapid transit system for New York City.

Theodore Cooper (1839-1919), after gaining experience as an engineer with the Troy and Greenfield Railroad, worked as a consultant for the New York and Boston Rapid Transit Company.

Walter Katte (1830-1917) did engineering for several roads and was a division engineer of the Belvedere and Delaware Railroad before he went to New York City in the mid-1870s, to become chief engineer of the New York Elevated Company. He built the first sections of the Third Avenue and Ninth Avenue elevated structures between 1877 and 1880.

Charles Sooysmith (1856-1916) spent two years with the Atchison, Topeka, and Santa Fe before becoming a consultant first on bridge foundations and then on the Underground Transit Railway of New York.

The first major subway in America opened in Boston in 1897. New York pioneered elevated railways, which in 1890 extended 33 miles. Chicago had elevated 13.5 miles of track in 1895 and was judged a model at the time. The trains rode on a structure made entirely of basic steel and incorporated the advanced techniques of the main-line railway bridge builders.

When the trains came to the cities, the urban population

gained mobility, and people could expand their view of their world, beyond the neighborhood, to take advantage of the centers of culture that cities were becoming.

The railroad and the American imagination

In the final chapter of this study, Leo Marx writes that there is a "special affinity between technology and America. . . . The success of the industrial enterprise, in turn, has intensified [Americans'] commitment to an ideal of progress that entails the most rapid possible rate of technological innovation."

Marx continues, "Not many inventions have aroused excitement like that which accompanied the construction of the American railroads. Almost as soon as the new machine appeared, in 1828, its economic import became apparent. By accelerating the pace of the westward movement and creating vast new markets for manufactured goods, the railroad quickly stimulated the over-all process of industrialization.

"It confirmed the predictions of men like Tench Coxe and Alexander Hamilton, who had foreseen (in the 1790s) that conditions once universally regarded as obstacles to America's economic growth would prove to be stimulants. Thus the abundance of land and the scarcity of labor, far from perpetuating the 'underdeveloped' character of the economy, now increased the demand for labor-saving machinery and, in general, quickened the rate of economic growth. Between 1830 and 1860 the nation put down more than 30.000 miles of railroad track, pivot of the transportation revolution without which industrialization under American conditions would have been impossible."

"In addition to its effect upon the economy," Marx writes, "the railroad had an immense impact upon the public imagination. Within a few years the locomotive (variously known as the 'iron horse,' 'fire-Titan,' etc.) became a kind of national obsession. Its attributes were such that it seemed the very embodiment of the Age of Steam: fire, iron, smoke, noise, motion, speed, power. Newspapers and magazines of the period were filled with accounts of railroad projects, railroad speed, railroad accidents, railroad profits—the lore appearing in songs, poems, political speeches and stories, both factual and fictional. Here is the way Ralph Waldo Emerson describes the frenzy in 1848:

" 'The Railroads is the only sure topic for conversation in these days. That is the only one which interests farmers, merchants, boys, women, saints, philosophers, and fools. . . .'

"During the 1840s, as Emerson testifies, the image of the railroad became what might be called a cultural symbol. . . . It was taken to represent man's newly acquired power over nature, and the idea of history as a record of virtually inevitable improvement or, in a word, progress."

Great projects build nations

How did these analysts from the early 1960s see the space program, in comparison?

They knew, as early as the first days of the Apollo program, that the impact of the space program would be even more wide-ranging and profound.

In his summary of the comparison between the impact of the railroads and the space program, Fogel sees the main impact of the railroads as facilitating "processes and activities which were well under way prior to their advent."

"With respect to the development of technology, the experience of the railroads offers little basis for assuming that the devices required for space transportation will lead to innovations that markedly affect productive techniques in other spheres of activity. Most of the devices invented to improve railroads had no significant applications outside of this industry. And in the case of Bessemer steel, a product with many applications that was clearly promoted by railroad requirements, the economy independently produced an extremely effective substitute, namely open-hearth steel.

"The difference is that rockets open up new areas not accessible before by any other means. In that, it will create new knowledge. . . . The space effort has a chance of affecting economic life far more radically than did the railroads. Examination of the railroad experience cannot aid in predicting the value of the scientific knowledge that may be gained from space exploration."

But this judgment is too harsh. The study of the railroads does give a glimpse of the characteristics of great projects that mobilize a nation, and advance society.

If the railroads could create wholly new engineering fields, and revolutionize science and engineering curricula, the space program could do so even more. When the railroads brought mail, newspapers, and material goods from the rest of the nation, they uplifted the culture of the rural and backward parts. Through applications of space technology, such as satellite communications, entire libraries are now at the fingertips of students and young people anywhere in the world.

The fascination of young and old alike with the majesty and glory of the iron horse, since the advent of the railroad one and a half centuries ago, can be seen on the faces of observers of all ages today, watching a rocket lift off into space. Where you are going and what you will find is still left to the imagination.

Only a few could begin to imagine what the impact of space exploration would be on society 35 years ago—in medicine, weather prediction, agriculture, machine tools, new materials. But the mobilization by American System economists, entrepreneurs, the Army, President Lincoln, and people in many towns and cities, to create an iron land-bridge from one American shore to the other, is indeed comparable to the effort of this nation in the 1960s to put a man on the Moon.

The analogy that can be drawn between the building of the American railroad and the efforts to land a man on the Moon, is that it is the accomplishment of such great projects that builds a nation.