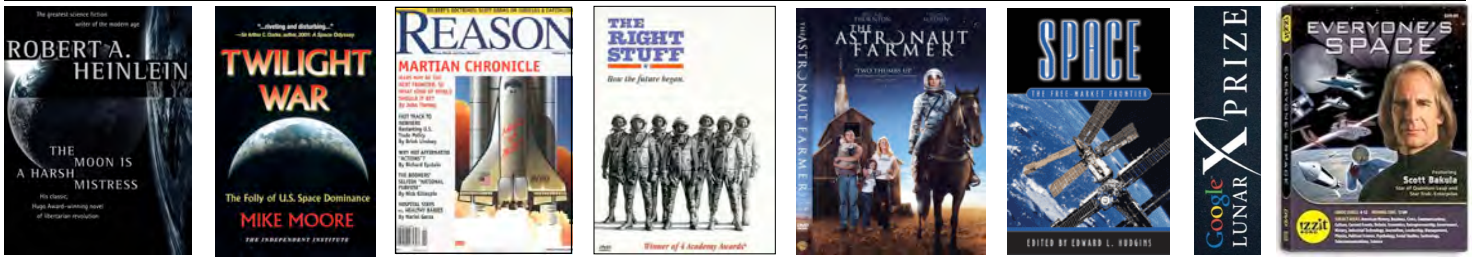
The Economics of Space Exploration

Contests, Entrepreneurship, and Special Interests in Space

Macinac Center Debate Workshps Space Topic Study Guide **October, 2011**



Can we return to the Moon for just $30 million? Though a fraction of total funds needed to land a rover on the Moon, the *Google Lunar X PRIZE* contest has inspired over dozen teams to begin design and development, and assisted their efforts to raise funds for lunar exploration. The *Google Lunar X PRIZE* offers $30 million "to the first privately funded teams to safely land a robot on the surface of the Moon, have that robot travel 500 meters over the lunar surface, and send video, images and data back to the Earth." (Read about the moon exploration contest at: www.googlelunarxprize.org)

Contests and private funding have a long history of enabling exploration across land, sea, air, and now outer space. Dava Sobel's *Longitude* tells of the British government's £20,000 prize to discover a way to measure longitude, to increase ocean exploration.

The Ansari X PRIZE was modeled after the Orteig Prize, won by Charles Lindbergh in 1927 for being the first to fly non-stop from New York to Paris, and mirrored the hundreds of aviation incentive prizes offered early in the 20th century that helped create today's $300 billion commercial aviation industry. Dr. Peter Diamandis designed the prize after reading The Spirit of St. Louis *about the winning of the Orteig Prize. ... The Ansari family [became] the title sponsors of the first X PRIZE, jumpstarting 26 teams from 7 different nations to pursue their passions by competing for the prize. Those 26 teams combined spent more than $100 million to win the prize. Since SpaceShipOne won the prize, there has been more than $1.5 billion dollars in public and private expenditure in support of the private spaceflight industry.* space.xprize.org/ansari-x-prize

Scaled Composite's SpaceShipOne wins the Ansari X Prize

Charles Lindberg wins the Orteig Prize for crossing the Atlantic.

Lunar X Prize competitors

Arrayed against the entrepreneurs and enterprises of the New Space Industry, are the cost-plus contractors of the Old Space industry. NASA's just-announced deep space rocket, with its $35 billion price tag, would be built cost-plus space contractors. To get Congressional funding NASA and lobbyists will try to undermine less-expensive New Space launch systems and space exploration projects. NASA and the Old Space contractors are accustomed to cost-overruns (and profits from cost-overruns): costs that include lobbying Congress for projects like the new "monster rocket" (see page 8). Space exploration's future is now being debated from high school to Congress.

The Race Back to the Moon

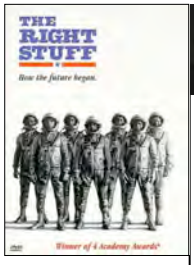
Returning man to the moon is less rocket *science* than rocket *engineering*. NASA's success as a research and development organization contrasts with its inability over decades to reduce costs for transporting payloads into space. The research and design skills for developing new technologies differ from the vision and capabilities to manufacture and operate commercial launches and moon landings.

NASA's excelled with early rocket and moon rover designs. But from there, competing commercial engineering teams can better advance space launch and moon rover technologies than central bureaucracies.

In a competitive market, diverse design options are developed and tested. NASA's Space Shuttle turned out to be way too expensive, slowing space exploration for decades.

Jeff Greason, President of XCOR contrasts the very different economics of commercial aerospace transportation in a recent TED talk see link below). The Soyuz rocket and Boeing 747 are made of aluminum and carry about the same amount of fuel, and the 747 is more complex technology than the Soyuz or Space Shuttle. But where the Space Shuttle is disassembled after each flight to check for wear, 747s take off safely soon after each landing. New rockets from XCOR and other firms are designed to these commercial standards, and the costs of launching people and payloads into space are being drastically reduced.

Beyond the debate over launch vehicles is a broader debate over manned vs. unmanned exploration, which highlights NASA long dependence on public relations from astronauts into space instead of just boring robots. But modern robotic vehicles are better for most space exploration, and astronauts have been called "spam in a can" for some missions.



The Right Stuff – both the book and movie – show the history of the heroism and great accomplishments of the U. S. space program. But top-down space enterprise tends to be costly.

Moon Express, a contender for the Google Lunar X PRIZE, recently hired a team to commercialize micro-rovers (story at right). This is along the lines of NASA's original mission to research space technology and fund initial development, but then to allow private firms to improve and commercialize space exploration technologies.

Dozens of private space firms have failed, losing millions of investment dollars. Because no one can guess which rocket or moon rover designs are best, this searching and discovery process is the key to future space exploration. Jeff Greason of XCOR makes this point, noting that the various private space launch vehicles in development have dramatically different designs.

"Astropreneur" David Gump's LunaCorp was profiled in *Wired* in 2003, but has since gone out of business. David Gump authored *Space Enterprise: Beyond NASA*, published before the 1980s debate topic on space exploration. But now 26 teams have joined this new race to the moon.

moon express

Moon Express Hires FIRST Robotics Champions to Develop Lunar Robots

12 september 2011

MOUNTAIN VIEW, Calif. — Moon Express, a Google Lunar X PRIZE contender, has announced that it has established the "Moon Express Robotics Lab for Innovation" (MERLIN) and hired a team of the nations' brightest engineering students who became international superstars through the FIRST Robotics Competition.

http://moonandback.com/2011/09/12/moon-express-hires-first-robotics-champions-to-develop-lunar-robots/

MERLIN will develop robotic technology supporting the company's lunar exploration missions under the leadership of Marco Chacin, a graduate of the International Space University who holds a PhD in Aerospace Engineering and developed robotic solutions for the JAXA/ISAS "Hayabusa" asteroid sample return missions.

The engineering team hired by Moon Express was mentored at the NASA Ames Robotics Academy, where they also developed innovative lunar micro-rover concepts. "MERLIN is formed around the best and most accomplished young robotics engineers," said company co-founder and CEO Bob Richards.

On Newsstands Now Issue 11.05 | May 2003 *www.wired.com/wired/archive/11.05/moon.html*

The Race Back to the Moon

Pg 1 of 4 >> Print, email, or fax this article for free.

Astropreneurs are counting down for a return to Apollo country. The first small step: a satellite atlas of the lunar surface. The next giant leap: ice mining, helium farming, and a launchpad to the solar system.

By Tom McNichol

For David Gump, the journey of 239,000 miles begins from a squat office building tucked behind the multiplex 14 in Fairfax, Virginia. Here, at the headquarters of LunaCorp, the commercial space company he cofounded in 1989, Gump has been keeping a lunatic dream alive through boom and bust: to boldly go where no private venture has gone before - to send the first business model to the moon and return it safely without losing his shirt. "Most space projects have way too many zeros on the end," says Gump, a slender, bespectacled man whose unassuming appearance belies his outsize plans. "You've got to be able to get something that's more in the $20 million range."

Ian White
After 15 years of trying to get a private lunar mission off the ground, LunaCorp cofounder David Gump is slated to take off next year. Eventually roving "telepresence portals" will beam back the full experience to Earthside theme parks.

Students attending the Mackinac Center Debate Workshops may be interested in the Kansas State Fair Demonstration Debates. I had the opportunity to offer short comments on the economics and history of the cases, arguments, and evidence.

Debate One: Allow Joint U.S./China Space Exploration

The affirmative ended the Congressional ban on joint U.S./China space projects and argued for NASA to work with the Chinese government on future space missions. China's economy will allow more spending on space projects, both scientific and military. Working with China, the affirmative argued, would foster better relations. I noted that the case assumes governments best manage space exploration, and that China's state enterprises have accumulate vast debt, distorting the Chinese economy. Plus, in recent years, dozens of small firms in the dynamic *New Space Industry* are advancing space exploration technologies in the U.S..

Also, China's historical experience as a technology leader exploring the world's oceans, offers a cautionary tale of what can go wrong with expensive state-sponsored ventures (article at right).

Debate Two: Mining on the Moon

The affirmative called for the Federal government to launch a new program to establishing mining operations on the moon. The affirmative claimed only thirty years of oil reserves exist and we need to lunar mining for new energy sources. This seems unlikely given recent huge oil and gas discoveries ("Report says we have more oil than we thought," *Houston Chronicle*, Sept. 15, 2011). Moon mining might be a profitable venture, but would require inexpensive launch capabilities, plus an array of new technologies. Robert Heinlein's classic novel *The Moon is a Harsh Mistress* outlined the technology and potential for future lunar mining colonies. In his novel, mining on the moon starts with penal colonies similar to past British penal colonies in Australia.

Debate Three: Asteroid Mining

The third debate was over a proposal for mining near-Earth asteroids, and argued the benefits of gathering rare earth metals and other minerals. The affirmative claimed the venture would cost $300 billion and earn $1 trillion in seven years. I noted that though China is now the low cost producer, rare earth minerals can be found in the U.S., other countries, and in large quantities under the oceans. Mining deep under the sea would be expensive, but likely less expensive than mining asteroids. A powerful side benefit for the affirmative, however, would be developing the technology to divert asteroids heading toward Earth.

-- Greg Rehmke, grehmke@gmail.com

www.spacedaily.com/news/oped-03zzx.html

Nostalgia For Medieval Explorers Won't Make Us Space Explorers

Cheng Ho's travels took him far at the time, but left China in no better position to confront the centuries of decline it has faced until the most recent years.

by Jeffrey F. Bell • Honolulu - Dec 03, 2003

Talk to "Space Cadets" long enough and they will inevitably start using historical analogies to "successful" sea exploration programs in order to promote their particular vision for future space exploration. But it is the historical failures that shed more light on the state of space efforts today.

Living in Hawai'i, I constantly encounter references to the great Polynesian canoe voyages. Another popular model is the age of European exploration that started with Columbus and Vasco Da Gama. Both had an immense influence on human history, so Space Cadets love to point to them to describe the potential for the exploration of space.

More appropriate lessons can be drawn from two "unsuccessful" sea programs. One which does get a certain amount of play is the Chinese Empire's program of "tribute fleets" that roved throughout the Indian Ocean in the 15th century. Science-fiction writer Vernor Vinge has even named his future interstellar trading culture after the most famous commander of those fleets, Admiral Cheng Ho. [titled: *A Deepness in the Sky*]

The Space Cadet history of Cheng Ho's voyages goes like this (with modern analogies in parentheses): Far-seeing palace eunuch-administrators (JFK's New Frontiersmen) funded an immense program of exploratory voyages (Apollo) that extended Chinese influence and culture throughout the Indian Ocean.

The size and technical sophistication of these ships was far in advance of the pitiful Portuguese (Soviet) caravels that were creeping down the West African coast at the same time. When Cheng Ho was on the verge of rounding the Cape and reaching Europe, a palace revolution replaced the eunuchs with Confucian scholars (Great Society welfare-staters / Nixon Administration warmongers) who lacked the vision to appreciate the value of oceanic exploration. The new administration cut seafaring out of the budget. Eventually, the building of ocean-going ships was banned, China turned inward and left the world of the future to be dominated by Europe (USSR / Japan / Red China).

But some years ago, I read some of the actual literature on that short period of Chinese oceanic voyaging. The real story is that those tribute fleets were very much like our current space program: vastly expensive, but producing no useful results other than propaganda. At each port stop, the local sultans or maharajas proclaimed themselves vassals of the Celestial Emperor, expensive gifts were exchanged, and then the fleet sailed on.

The Chinese didn't get any colonies, forts, naval bases, or trading posts. They seem not to have even collected taxes or tribute on a long-term basis from the places they visited. There was no increase in trade or industry that can be traced to Cheng Ho's voyages.

The emigration of the Overseas Chinese population so prominent in the economic life of this area today is completely unconnected to Cheng Ho. The Chinese Empire spent a huge amount of public money on these voyages and in return it got a short-lived boost in prestige and a few alien animals for the Emperor's zoo.

pajamasmedia.com/blog/how-congress-sabotages-space-exploration/

How Congress Sabotages Space Exploration

We cannot afford to continue to do space business as usual as the nation becomes more and more fiscally strapped.

July 20, 2011 - 12:14 am - by Rand Simberg

The Space Shuttle Atlantis closed its hatch at the International Space Station on Tuesday, for the last time, not just for that orbiter, but for any. It separated from the ISS, and will perform a few final tasks in orbit over the next couple days. Then, weather permitting, it will fire its orbital maneuvering engines to slow itself, and start its long, last fall back into the atmosphere, with a final stop of the wheels on the runway in Florida, where it will spend the rest of its days in a museum at the NASA Kennedy Space Center. After a little more than three decades of operation, the Space Shuttle program will be over.

Ironically, it takes place on the forty-second anniversary of the first landing on the moon (July 20th), an event that many at the time thought would kick off a great age of space exploration, to be followed by lunar bases and human missions to other planets. In fact, the Shuttle program, initiated shortly after that monumental achievement, was thought to hold the key to the rest of the solar system. Instead, it served to keep us trapped in low earth orbit for almost four decades.

With the Shuttle's retirement this week, the nation is now dependent on the Russian Soyuz to not only get its astronauts to and from the ISS, but to continue to provide the "lifeboat" in the event of an emergency in orbit. There is now no backup to that system — if something goes wrong with it, we will have no access at all, which could be disastrous for not just those aboard the station, but for the facility itself.

This situation has led some (including some who should know better) to panic and go off on flights of fancy about keeping the system going. Even former NASA administrator Mike Griffin, who created a controversy a few years ago by declaring the program a "mistake," [see insert] is now saying that it should go on.

But it's simply impossible at this point to close the "gap" with the Space Shuttle. As former Shuttle program manager Wayne Hale warned at his blog three years ago, the supply chain of expendable parts (such as external tanks) is gone, and couldn't be recreated for two or three years. And beyond that, it would simply be impractical to fly safely with only three orbiters left.

The end of the Shuttle program ends more than the Shuttle era. Historians in the future will note that it ended a false notion, one half a century old: that humanity would open up space through the application of command-economy government programs. The future, even the immediate future, of human spaceflight lies not with a single type of vehicle developed by and for a massive government bureaucracy, but with public/private partnerships that create a robust, competitive commercial spaceflight industry. This is the only practical way forward to close the gap between the end of the Shuttle and new domestic capability that will eliminate our reliance on the Russians.

Continued on page 5

reason.com/archives/ 2011/ 05/23/lunar-lunacy

Lunar Lunacy Space Waste

Peter Suderman from the July 2011 issue of *Reason*

Congress may not be very invested in sending Americans back to the moon. It is nevertheless forcing the National Aeronautics and Space Administration (NASA) to spend millions of dollars on a lunar program going nowhere.

In March, Congress voted for a three-week continuing budget resolution that compels NASA administrators to continue spending $1.4 million a day—about $29 million over the course of the three-week budget extension—on Constellation, an initiative aimed at sending American astronauts to the moon. This despite the fact that the Obama administration shut down the program last year.

This isn't the first time Congress has voted to continue funding the zombie program. Last summer the legislature approved a short-term extension of Constellation's funding while attempting to negotiate a new budget. As negotiations dragged on, Congress passed more short-term continuations. Each time, Sen. Richard Shelby (R-Ala.) inserted language forcing NASA to continue funding Constellation even though it had been closed. Not surprisingly, much of that money goes to Shelby's constituents.

Nor was Congress unaware of the problem. In June 2010, NASA Administrator Charlie Bolden wrote a letter to Shelby warning that continuing to fund the defunct lunar program would waste more than $200 million. By the time the March extension passed, NASA had blown more than $250 million on keeping the program alive.

www.usatoday.com/tech/science/space/2005-09-27-nasa-griffin-interview_x.htm

NASA administrator says space shuttle was a mistake

By Traci Watson, USA TODAY
Posted 9/27/2005 11:03 PM

The space shuttle and International Space Station — nearly the whole of the U.S. manned space program for the past three decades — were mistakes, NASA chief Michael Griffin said Tuesday.

NASA chief Michael Griffin on the space shuttle: "It is now commonly accepted that was not the right path."

In a meeting with USA TODAY's editorial board, Griffin said NASA lost its way in the 1970s, when the agency ended the Apollo moon missions in favor of developing the shuttle and space station, which can only orbit Earth. ...

Congress Sabotages Space Exploration (continued. from page 4)

Unfortunately, Congress, caring more about space pork than progress, continues to have other plans.

Last year, it passed an authorization bill demanding that NASA build a new heavy lift vehicle by 2016, using Shuttle components and contracts. They called it the Space Launch System, but others have called it the Senate Launch System, after the rocket scientists on the Hill who came up with it. Absurdly, they expect NASA to build this vehicle faster than it was going to deliver the Ares launcher from Constellation, with less funding, and they want to use it as a launcher for an overpriced NASA-developed capsule to ISS, despite the fact that it is ridiculously oversized for that mission. In the markup that came out of the Commerce, Justice, and Science Appropriations Committee last week, they insisted on funding these for three billion dollars for next year, an increase over NASA's request (though below the level authorized last year, and not enough to actually make the program successful, if indeed there is any amount of money that can do that). Given that the overall NASA budget is being reduced to pre-2008 levels, they got the money for this in part by reducing the funding for the commercial crew program, from the $850 million request to a little over $300 million.

In other words, they are starving off funds from the one program that can quickly close the post-Shuttle gap and pouring it into a rocket to nowhere, but one that continues to generate jobs in the states and districts of the congresspeople and senators on the space committees. Beyond that, they also cut the funding to the technology programs that offer hope of actually making travel beyond earth's orbit practical and affordable, demonstrating once again that while they talk a good game of wanting NASA to send humans out to explore, such a goal takes a distinct backseat to keeping the campaign contributions and votes coming.

Fortunately, while they can slow down American enterprise, they can't stop it (unless they make it illegal for private entities to go into space). SpaceX, United Launch Alliance, Boeing, Sierra Nevada, Bigelow Aerospace and others are going to continue to move forward and some time, probably within the next year (particularly if SpaceX docks a Dragon capsule with the ISS later this year, as currently planned), will be looking better and better. In fact, in an authorization committee hearing last week with administrator Bolden, even some of the committee members are starting to understand the implications of their disastrous policy preferences: We're still talking late this decade, early '20s before we have a human-rated [SLS] vehicle," [Bolden] said. That, a member of the committee later noted, makes it unlikely the MPCV would be able to serve as the backup for commercial providers for accessing the ISS unless the station's life is extended beyond 2020.

As the commercial providers continue to meet critical milestones at modest costs, and the government rocket program continues to be bogged down in mismanagement and bureaucracy, just as Constellation was, it will become clear to everyone else in Congress that we cannot afford to continue to do space business as usual as the nation becomes more and more fiscally strapped. As not just the Shuttle era, but the government-directed human spaceflight era ends, we're finally going to get a space program that looks like America, whether the defenders of the status quo like it or not.

www.thefreemanonline.org/featured/the-sources-of-invention/

The Sources of Invention

by John Jewkes

The author [was] Professor of Economic Organization in the University of Oxford. This article first appeared in the January 1958 issue of Lloyds Bank Review [and] was reprinted by the Foundation for Economic Education. Page numbers in brackets. See URL for full article.

It seems to be almost universally assumed that the launching of the space satellites was made possible only by employing vast teams of technicians working together in large research institutions under close central guidance and with unlimited resources and equipment. This may be true, although nobody in the Western world can actually know that it is so. Any suggestion that the difference between failure and success might have resulted from a pathbreaking discovery by some worker not in a large institution and perhaps not even interested primarily in high- altitude rockets would, nearly every where, be instantly dismissed as ludicrous. All this is indicative of the degree to which we are now dominated by the doctrine that technical progress can come only from mass attacks upon set problems.

In fact, a glance at the history of the high-altitude rocket hardly supports such a theory. Some of the more important early scientific writings on this subject, published in 1903, were those of a Russian schoolmaster, [p. 115] K. E. Ziolkowsky. He made many fundamental contributions to rocket technology. (Russia was probably further ahead of other countries in thought and work on rockets in 1908 than now.) Perhaps the most important scientific contribution to rocket theory, however, was made by Hermann Oberth, a teacher of mathematics in Transylvania, who in 1928 published his classic, *By Rocket into Interplanetary Space*.

German Rocket Experts

Between the two world wars practical interest was maintained by a group of young German amateurs, some of whom were destined to become later outstanding figures in this field. During the war the German military authorities took up the development of the rocket and finally produced the V2, which covered a distance of 120 miles with a deflection of only 212 miles from the target, reached a speed of 3,000 miles per hour and a height of nearly 60 miles. When Germany was finally overrun, the Peenemünde experts were scattered. Some went to the United States and Britain; more finished up in Russia.

Considering the rapid progress made by Germany in a relatively short period during the war, the development of high-altitude rockets since that time seems to have been fairly slow everywhere; for by 1945 there was no doubt that a satellite could be placed in the sky by the use of rockets and there was no great mystery about how, in general, this could be done. The fundamental discoveries in regard to high-altitude rocket propulsion, as distinct from the refinement and development of these [p. 116] ideas, were made by independent enthusiasts working with limited

resources under discouraging conditions and for long ridiculed or ignored by the main bodies of organized science and technology.

A New Theory of Progress

Even, however, before atomic energy and the sputniks, new notions had been gaining ground about how inventions could best be stimulated and how scientists and technologists might be employed to the best effect. (These ideas began to be strongly advocated only during the 1930's. Before that time, it will be recalled, it was commonly believed that the problem of production was solved and that the distribution of wealth was the important task to be dealt with; that technical progress was perhaps going on too quickly and that scientists and technologists were probably doing more harm than good in the world.)

The new doctrines really amount to a claim that the world has suddenly become a different kind of place, that the lessons of the past have largely become irrelevant and that we must all now adjust ourselves and our thinking accordingly. This "modern" view can be summarized as follows.

In the nineteenth century, most inventions came from the individual inventor who had little or no scientific training and who worked largely with simple equipment and by empirical methods and unsystematic hunches. The link between science and technology was slight.

In the twentieth century, the argument runs on, the [p. 117] characteristic features of the nineteenth century are rapidly passing away. The individual inventor is becoming rare; men with the power of originating are largely absorbed into research institutions of one kind or another where they must have expensive equipment for their work. Useful invention, in particular, is to an ever-increasing degree issuing from the research laboratories of large firms which alone can afford to operate on an appropriate scale. There is increasingly close contact now between science and technology. The consequence is that invention has become more automatic, less the result of intuition or flashes of genius and more a matter of deliberate design. The growing power to invent, combined with the increased resources devoted to it, has produced a spurt of technical progress to which no obvious limit is to be seen.

In this article are set down some of the results of an inquiry, shortly to be published in full,1 designed to test these opinions against the observable facts. It was hoped in this way to make some contribution to a better understanding of the dynamics of industrial societies. The study, it must be repeated, covered a period before atomic energy and space satellites. It may be that these latest spectacular discoveries, and the circumstances in which they have arisen, rob earlier experience of all pertinence for thinking about the future. I personally have doubts about this but cannot enlarge on them here. [p. 118]

Further, the study was confined to inventions as contrasted with the development of those inventions; it was concerned with the early crucial periods of radical innovation and not the later stages of improvement and exploitation of the original discoveries. It is, of course, impossible to draw a sharp dividing line between the two. On the other hand, it would be futile to deny that some new ideas are more revolutionary than others, that certain conceptions start a long chain of consequential improvements and that, unless the flow of these seminal ideas can be maintained, technical progress will finally come to a stop.

Twentieth-Century Inventions

The first task was to pick out a group of twentieth century inventions which might be regarded as a fair cross-section of the technical progress of the past fifty years; to make as detailed a study as possible of the conditions under which they had arisen and, in particular, to try to identify the respective parts played by individual inventors, the research activities of firms of varying size, of universities, and of other institutions where research is conducted. A list of about sixty inventions was studied, ranging from acrylic fibers to the zip fastener, from air conditioning to xerography.2 [p. 119]

The clearest conclusion emerging from the inquiry was that simple generalizations are not possible. The important twentieth century inventions have arisen in all sorts of ways and through the activity of all the different possible agencies. More than one-half of the cases can be ranked as individual invention in the sense that much of the pioneering work was carried through by men who were working on their own behalf without the backing of research institutions and often with limited resources and assistance or, where the inventors were employed in institutions, these institutions were, as in the case of universities, of such a kind that the individuals were autonomous.

The jet engine was invented and carried through the early stages of development almost simultaneously in Great Britain and Germany by men who were either individual inventors unconnected with the aircraft industry or who worked on the airframe side of the industry and were not specialists in engine design; the aircraft engine manufacturers came in only after much pioneering had been carried on. The gyro-compass was invented [p. 120] by a young man who was neither a scientist nor a sailor but had some scientific background and was interested in art and exploration.

The process of transforming liquid fats by hardening them for use in soap, margarine, and other foods was discovered by a chemist working in an oil industry, who pursued his researches and his efforts to get the process adopted, singlehanded. The devices which made practicable the hydraulic power steering of motor vehicles were primarily the work of two men, one of whom worked strictly on his own, while the other was the head of a small engineering company.

The foundations of the radio industry were laid by scientists; but the majority of the basic inventions came from individual inventors who had no connection with established firms in the communications industry or who worked for, or had themselves created, new small firms. In the case of magnetic recording, the early crucial invention came from an independent worker, as did a number of the major inventive improvements; the interest of the companies arose much later. The first successful system for the catalytic cracking of petroleum, which opened up the way for many later advances, was the product of a well-to-do engineer who was able to sell his ideas for development to the oil companies.

No Standard Pattern

The history of the evolution of the cotton picker reveals two main lines of progress: in each case, individual [p. 121] inventors working with limited resources were able to take their ideas to the point where large firms were prepared to buy or license their patents for subsequent development. Bakelite, the first of the thermosetting plastics, was produced by a brilliant sole investiga-

tor. The first, and still the most important, commercially practicable method of producing ductile titanium was conceived of by a metallurgist working in his own laboratory.

In the application of automatic transmissions to motor vehicles, the credit for mechanical novelty has to be shared between individual inventors and companies, but the former should probably rank above the latter; actually, the ideas of a shipbuilding engineer lie behind much of the modern progress, but both in Britain and the United States inventors working singlehanded have contributed a great deal to the present-day mechanisms. Up to 1938, only one large aircraft manufacturer had taken much interest in the helicopter and even that only as the result of the personal interest of the head of the firm: the progress was made by the enthusiasm of individual inventors, usually with limited resources, obtaining backing in unlikely quarters in a manner which would parallel the many stories of "heroic" invention in the nineteenth century.

To mention one or two inventions from the field of consumer goods, the groundwork for the successful Kodachrome process was laid by two young collaborators, both musicians, whose ideas were taken up by a large photographic firm; the safety razor came from two [p. 122] individuals who struggled through financial and technical doldrums to great success; the zip fastener came from the minds of two engineers and was only taken up for large- scale production many years later; the self-winding wrist watch was invented by a British watch repairer. ...

The Communists Had None

One significant exception is that, in none of the sixty cases studied, had contributions been made by Russian workers subsequent to the Revolution. Before that date, numerous names of distinguished Russian contributors crop up: the early Russian work in rockets has already been mentioned; in the early efforts linked with television occurs the name of Rosing; Zworykin, who later on in the United States was to make one of the vital contributions to the perfection of television, acquired his interests in this field in St. Petersburg before the first world war; Sikorsky, the great American helicopter pioneer, had in fact built two helicopters in Russia as far back as 1909.

But, after the Revolution, it seems clear that Russia made no important contributions in radar, television, the jet engine, the antibiotics, the man-made fibers, the newer metals, the catalytic cracking of petroleum, the continuous hot strip rolling of steel, silicones or detergents, until others had shown the way and revealed what could be done. [p. 126] ...

Size May Be No Advantage

[I]t is erroneous to suppose that those techniques of large-scale operation and administration which have produced such remarkable results in some branches of industrial manufacture can be applied with equal success to efforts to foster new ideas. The two kinds of organization So that large research organizations can perhaps more easily become self-stultifying than any other type of large organization, since in a measure they are trying to organize what is least organizable. The director of a large research institution is confronted with what is perhaps the most subtle task to be found in the whole field of administration; a task which calls for a rare combination of qualities, scientific ability commanding the respect of colleagues, and also an aptitude for organizing a group.

There are many cases to support the conclusion that a large research organization may itself prove to be an obstacle to change. Ideas emanating from outside may be belittled or passed over. "Is not every new discovery a slur upon the sagacity of those who overlooked it?" And it will always be seductive for an established organization to take the smaller risks and more prudent routes when [p. 133] the rare and larger prizes are likely to be found in other directions.

> [Small and large organizations] are subject to quite different laws. In the one case the aim is to achieve smooth, routine, and faultless repetition, in the other to break through the bonds of routine and of accepted ideas.... a large research organization may itself prove to be an obstacle to change.

Can the Pace Be Forced?

Here, then, is the dilemma which confronts any community trying to make the best of the native scientific and technical originality of its members. On the one side are the views of those, at the moment it seems in the majority, who conceive of the possibility of forcing the pace, as it was recently put by one research director:

We find the self-directed individual being largely replaced by highly organized team attack in which we employ many people who, if left entirely to their own devices, might not really be research-minded. In other words, we hire people to be curious as a group . . . we are undertaking to create research capability by the sheer pressure of money . . . .

On the other hand are the fears of those, at present much in the minority, who suspect that such forcing tactics will mean that we may frustrate the awkward, lonely, inquiring, critical individuals who, to judge by past experience, have so much to give but can so easily be impeded. To pose the question in concrete form: the last time that a new form of propulsion, the jet engine, came to be conceived it was pressed forward by individual workers who had to meet frustrations and indifference, even resistance, on the part of established institutions. We are, presumably, not at the end of such innovations; there may be other new forms of motive power to come. [p. 134] ...

It may be that there are no clear-cut answers to such weighty questions. But the study of the inventions of the twentieth century would seem to support the following generalizations. Knowledge about innovation is so slender that it is almost an impertinence to speculate concerning the conditions and institutions which may foster or destroy it. But, in seeking to provide a social framework conducive to innovation, there would seem to be great virtues in eclecticism. If past experience is anything to judge by, crucial discoveries may spring up at practically any point and at any time.

As contrasted with the ideal ways of organizing effort in other fields, what is needed for maximizing the flow of ideas is plenty of overlapping, healthy duplication of efforts, lots of the so-called wastes of competition, and all the vigorous untidiness so foreign to the planners who like to be sure of the future.

The full article provides many additional arguments and examples: www.thefreemanonline.org/featured/the-sources-of-invention/

SPACE FRONTIER FOUNDATION
http://spacefrontier.org/2011/09/15/monster-rocket/

Monster Rocket Will Eat America's Space Program

by Ferris Valyn on September 15, 2011

The Space Frontier Foundation called Wednesday's announcement by NASA that it will attempt to build Congress's giant monster rocket a disaster that will devour our dreams for moving humanity into space. Rather than breathing life into a dying space program, it may well kill new initiatives to greatly expand US space exploration and settlement efforts.

"It is a sad day for our space program," said Rick Tumlinson, co-founder of the Foundation. "The amazing possibilities offered by engaging commercial space to lower costs and develop a sustainable long term infrastructure to support NASA space exploration, settlement and a new space industry have been trumped by the greed, parochialism, and lack of vision of a few congressional pork barrelers intent once again on building a government super rocket. We've been to this party before, it was a bust then, and it will be this time as well."

The rocket, known as the Senate Launch System by most of the space community, was formally announced in the very building where it was conceived – the U.S. Senate's Dirksen office building. Not surprisingly, Senators and Congressmen proudly spoke of their contribution to this Frankenstein monstrosity, stitched together from various pieces of pork for congressional districts that have been working the system for months.

"Senator Nelson called the SLS a monster rocket and he's right," explained Bob Werb, co-founder and chairman of the board for Space Frontier Foundation. "Although they're trying to dress it up in the colors of the Saturn V, it's a Frankenstein rocket, built from rotting remnants of left over Congressional pork. And its budgetary footprints will stamp out all the missions it is supposed to carry, kill our astronaut program and destroy science and technology projects throughout NASA."

The Foundation is certain that much like Constellation before it, the Senate Launch System will never stay within its budget or schedule, and in the end will be cancelled. SLS will become the most cannibalistic program in NASA's history, consuming innovative programs attempting to lower costs by using commercial firms to fly astronauts into space, new technologies that would make exploration more affordable, and of course the payloads the new rocket is supposed to carry.

"The Senate's new Franken-rocket will fail, it will waste billions, it will never fly and it will destroy what little credibility our space program has left." said Foundation Executive Director Will Watson, "It is an un-American solution to a challenge we can solve in an American way with our own commercial space flight companies. If it is not stopped the SLS monster will be a death sentence for NASA's once great human space flight program."

www.space-access.org/updates/sau128.html

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Impossibly high NASA system development costs are the heart of the matter

We will ignore for the moment the arguments over whether the old-line NASA human spaceflight establishment is at this point capable of putting together an effective exploration program at any cost. The indisputable fact is that their costs for making the attempt have risen to unsupportable levels.

A NASA study last spring applied government project-cost estimating models to a recent commercial booster development. The result was a cost estimate for the same booster done the established NASA way of ten times the actual commercial development cost. This study also looked at the effect of a hypothetical streamlined version of traditional NASA system development methods, and came up with a cost estimate of "only" three or four times the actual commercial cost.

Note that these extreme cost ratios came from the type of tools used to come up with initial NASA project cost estimates. In another recent study, the GAO found that a dozen or so recent high profile NASA development projects actually cost on average over fifty percent higher than their initial estimates.

In other words, NASA major project development costs in recent years demonstrably ran roughly fifteen times higher than equivalent commercial project costs. Even with a streamlined "modified" version of traditional NASA procurement practices, costs still would run as much as six times the commercial equivalents.

In the current fiscal climate, this is a big problem for those of us who'd like to see NASA doing useful space exploration and technology development. It's apparently not at all a problem for those who see NASA primarily as a hometown jobs program. But that's a short-term outlook - in the long term, the ongoing expensive lack of results will inevitably bring NASA down. Ultimately, the real choice is, a new reformed NASA with a new and very different way of doing business, or no NASA at all. -- *SLS*

The Economics of Space Exploration study guide was prepared by Greg Rehmke for students attending the Mackinac Center Debate Workshops. Mr. Rehmke directs educational programs for Economic Thinking and is a member of the Mackinac Center Board of Scholars. Questions? Email: grehmke@gmail.com, or visit www.EconomicThinking.org

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