JUMP-STARTING THE SPACE FRONTIER BY GOVERNMENT PURCHASE OF COMMERCIAL ORBITAL PASSENGER SERVICE,
OR,
THE VALUE OF A GOOD CUSTOMER

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ABSTRACT

The Report of the President's Commission on Implementation of United States Space Exploration Policy (the Aldridge Commission) of June 2004 makes a breathtaking breakthrough in regard to the use of the commercial sector in the exploration of outer space. None-the-less, the report opines that the 'launch of human crews would remain the providence of the government for at least the near-term'. More recent NASA documents state that the basic crew exploration vehicle (CEV) 'design will enable ascent and re-entry into Earth's atmosphere'. In the mean time a nascent entrepreneurial orbital and sub-orbital passenger transportation business is starting to emerge. What are the potential effects of this seemingly small deviation from the entrepreneurial thrust contained in the Commission report?

High launch costs have prevented the opening of the space frontier, keeping the number of people venturing to space low. In turn, small numbers have been a disincentive to the commercial sector to enter the passengers to orbit business – until now. Entrepreneurs see the human passengers to space business as having a potentially very large and expandable (elastic) market. Yes, the Commission recommended using the commercial sector for cargo and freight. But people in space drives the need for cargo and freight beyond current levels, and not the other way around. If the government owns and operates its own vehicles will it insist that they be used for taking astronauts to and from the space station and the Earth to orbit portions of exploration missions after commercial alternatives appear? If so, an initial subsidy for the entrepreneurial space passenger business, which has both the incentive and potential to bring down launch costs, could disappear delaying the real opening of the space frontier.

1. Introduction

On January 14, 2004, President George W. Bush issued his vision for U.S. Space Exploration titled "Renewed Spirit of Discovery". Dubbed 'Moon, Mars and Beyond', the President issued an executive order a few days later establishing a Commission to investigate how this vision should be implemented. The Report of this Commission (the Aldridge Commission) of June 2004[1] makes some breathtaking breakthroughs in regard to the use of the commercial sector in the exploration of outer space. For example the words 'entrepreneurs' and 'entrepreneurial' are mentioned some 17 times, 'commercial' and 'commercialization' are mentioned 24 times and the phrase 'private sector' is mentioned 43 times. Among the welcomed recommendations is that of Recommendation 5-2 which stipulates

- the use of prizes to stimulate innovation in the private sector,
- tax incentives to stimulate increased private sector involvement in space,
- regulatory relief from laws that could unduly burden a new space industry and
- a re-examining of property rights in space.

The Report goes on to say that: "What is inherently governmental today will also change with time, especially if public mission objectives (e.g., to re-supply the International Space Station) are intentionally allowed to intersect and support wholly unrelated commercial opportunities, such as the development of launch technology in support of space tourism." Yet just a few paragraphs later it says: "The Commission also realizes that the launch of human crews requires extraordinary care and will likely remain the providence of the government for at least the near-term."

In response to the Report of the President's Commission and the original Presidential vision statement, NASA has issued it's own report titled: "The New Age of Exploration - NASA's Direction for 2005 and Beyond" as of February of 2005[2]. Strategic Objective 7 in the NASA document directly quotes from the vision statement to: "Develop a new crew exploration vehicle to provide crew transportation for missions beyond low-Earth orbit." Though the purpose of the crew exploration vehicle (CEV) is specifically to explore beyond low-Earth orbit, the NASA objective states that, "The overall crew transportation system that will evolve from the basic CEV design will enable ascent and re-entry into Earth's atmosphere." In the mean time a nascent entrepreneurial orbital and sub-orbital passenger transportation business is starting to emerge. What are the potential effects of this seemingly small deviation from the entrepreneurial thrust contained in the Commission report and the NASA objective statement?

2. Humans into Space: The Market High Ground

Why is the humans into space market such an important market, and why must it be developed by the commercial sector? First of all, the government has not and more importantly is not capable of developing the people into space market. The government develops vehicles using very bureaucratic layered processes, which means that the resulting vehicles are necessarily very expensive. Requirements for vehicle capability are driven by government agendas that may or may not be space related and not by the needs of potential commercial customers. Vehicle capability can be compromised by political deals (think space shuttle) and any funding for building or operating vehicles comes at taxpayer largess and taxpayers are not always sympathetic to the views of those who want to open the space frontier.

The humans into space market is not the first commercial space market. The first such was the communications satellite market, which started at the very beginning of the space age. There was a short time in the nineteen nineties when it was believed that the communications market would generate enough launch volume to fuel the development of a new generation of cheaper to operate vehicles. That expansion of the communications satellite market would have used constellations of low-Earth orbit (LEO) satellites to offer various voice and broadband services. Iridium, the only survivor of the LEO constellation boon offers voice services using a special, large by modern standards, handset that has so far limited its use to special applications. In hindsight, it is doubtful that the LEO constellations could have generated enough launch demand to create the next generation of cheap spaceships. The launch market for communications satellites simply is not a mass market – it doesn't directly interface with the general public. The services offered by these satellites are mass markets and do interface with the public, but the launching of the satellites used by these services are not. The services part of the market is elastic with regards to price because a drop in price leads to an increase in revenue. However the satellite component of the service is only a small part of the cost of providing the service. So reducing the price of launching these satellites by a large amount would reduce the overall cost of the service by only a small amount and the increased revenue of the overall service would not make up for the revenue lost by the launching companies for reducing their prices. Thus the communications satellite launching market is considered to be inelastic with regard to price because reducing the cost of launch leads to a loss of revenue. Increasing launch costs significantly would be counter productive as well since doing so would only induce telecommunication services companies to go to alternate, perhaps terrestrial technologies.

The people into space market, by contrast, is considered to be an elastic market and it is elastic over a wide range of prices. In order to understand the import of this, one needs to be acquainted, at least at a high level, with some basic marketing concepts[3]. A *demand curve* plots unit price on the vertical axis of a graph versus the number of units sold per year (the demand) along the horizontal axis. In the case of the people to space market, the unit price is the price of a ticket for a seat on the spacecraft. The number of units sold is the number of people buying rides into space. One expects demand to increase as the ticket price falls. If it increases sufficiently, revenue per year, which is unit price times the number of units sold per year, will also increase. When it does, demand is said to be elastic at that price. It should be noted that a demand curve is independent of time. It doesn't project when demand or revenue will increase. It similarly doesn't tell the difficulty of achieving a particular unit price. It just says, given a particular price point, what the demand (number of units sold) will be at that price point, and if there is a fluctuation around that price point, whether revenue will go up or down. Demand curves are plotted in many industries from actual sales data. Unfortunately there is little data to go on for the people into space market. There are a few data points however. There are the flights of Dennis Tito of California and Mark Shuttleworth of South Africa for the alleged price of twenty million dollars apiece. At the other end of the price scale are the ticket prices paid by passengers buying tickets on commercial airlines. In the year 2003, United States flag carriers carried almost 650 million passengers. In the same year 1.7 billion passengers flew worldwide[4]. Airline ticket prices are typically in the hundreds of dollars range. So from these two extreme vantage points plus projections from market surveys such as the Futron / Zogby "Space Tourism Market Study[5]" one can come up with an idealized demand curve which is shown in Figure 1.

3. A Thought Experiment in Power of Market Forces

The demand curve in Figure 1 assumes that the orbital passenger market starts off carrying only a few well paying private citizens into orbit. As prices to orbit come down, the number of people paying for trips into orbit goes up. It is important to note that the market may start off as something called space tourism, but it doesn't remain that as prices go down. In fact the market diversifies. As prices go down, people take trips into space for more and more different reasons. Just as air travel started off with thrill seekers and progressed to the diversified market that it is today, there is every reason to believe that travel to space would mature similarly.

3.1 Modeling the Commercial Orbital Passenger Market

A more formal statement of the *Price Elasticity of Demand* is that it is the percent increase in the rate of demand per percent decrease in the unit price. The idealized demand curve shown is a curve that is obtained when the Price Elasticity of Demand is assumed to be constant. With this assumption, the unit price is some initial price divided by the rate of demand raised to some power. In symbols

$$P = P_0 / Q^x \qquad (1)$$

where P is the unit price, P_0 is some initial unit price and Q the rate of demand. The revenue R is the unit price times the rate of demand Q (the number of units sold per year), or

$$R = P * Q = P_0 * Q^{1-x} = P_0^{1/x} * P^{(x-1)/x}. \qquad (2)$$

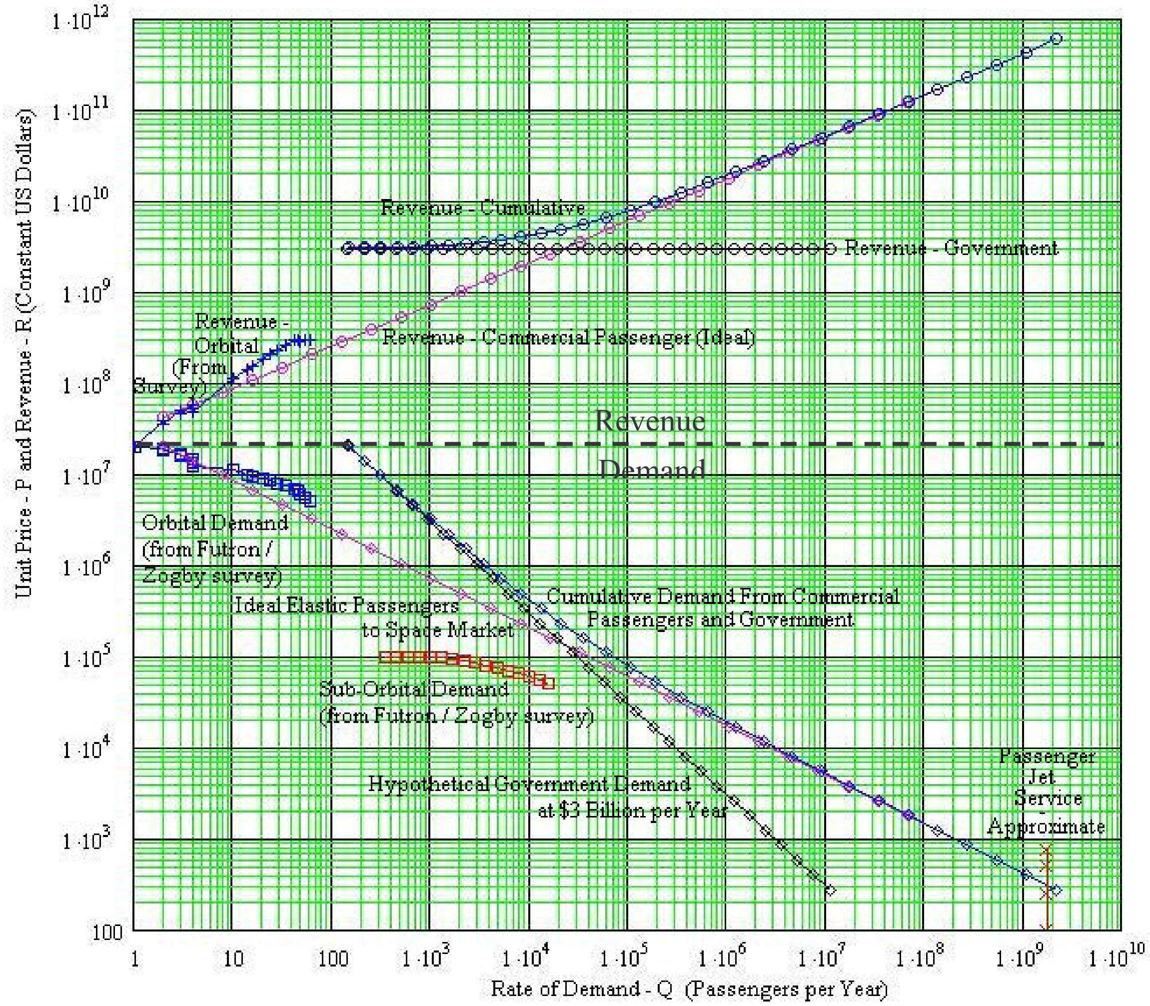


Figure 1 – The magenta line in the demand (bottom) half of the graph is the ideal demand curve for commercial passenger service to orbital space and beyond. This line is bounded by the Tito / Shuttleworth flights for about $20 million a piece and the results of the Futron / Zogby survey at the high end of the curve and commercial passenger jet service at the low end. The black line in the demand (bottom) half of the graph is the hypothetical demand from the government using $3 billion (about three quarters of the current shuttle budget) to pay for astronaut trips into space. The blue line in the demand half of the graph is the cumulative demand of these two markets. The revenue (top) half of the graph shows the corresponding revenues for each of the demand curves. The ideal commercial passenger market is shown to be elastic with regards to price because the revenue goes up as the price goes down in the corresponding demand curve. The government market is flat, neither elastic nor inelastic. The cumulative government / commercial orbital market is revenue flat when the government dominates the market but becomes increasingly elastic as the commercial market starts to dominate. The transition from government dominance to commercial dominance occurs in this particular scenario when about 20,000 passengers per year from each of the government and commercial sides pay about $150,000 per ride resulting in a cumulative revenue of $6 billion per year.

When the exponent x is less than 1, revenue goes up as unit price goes down (and demand goes up) and is elastic with regards to demand as has been previously stated. When $x = 1$, revenue is constant for all unit prices and demands and is neither elastic nor inelastic. When $x > 1$, revenue goes down as unit price goes down (and demand goes up) defining an inelastic market. When the logarithm is taken of both sides of (1) we find that $\log P = \log P_0 - x * \log Q$, or substituting $p = \log P$, $p_0 = \log P_0$, $q = \log Q$

$$p = p_0 - x * q. \qquad (3)$$

Thus when the ideal demand curve is plotted on a log / log scale one obtains a straight line with negative slope starting with a high-end unit price of about \$20 million (in the model P_0 was actually set to \$30 million to get a better overall fit). Fitting this line with the Tito / Shuttleworth - price / demand points on one end and the airline price / demand points on the other end, the exponent turns out to be close to ½ (the value actually used in Figure 1 was x = .54). Another reason to expect the demand curve for this market (a mass market) to follow close to a straight line in the log / log plot is because it is based upon the underlying distribution of wealth where there are lots of people in the middle and fewer and fewer people at the top of the wealth scale.

The demand curve doesn't tell how quickly the market traverses the curve to the right. The above mentioned Futron / Zogby survey on the other hand makes some projections on how quickly prices might go down and traffic volume go up for both orbital and sub-orbital trips. The baseline projection for orbital trips is shown as Figure 2.

The baseline projection makes the assumption that Russian Soyuz vehicles are used to carry passengers to the International Space Station during a twenty-year period. At the end of that period, 60 passengers per year are taking orbital trips into space at an average price of \$5 million providing a total revenue stream of \$300 million. No new launch technology is assumed to reach the 60 passengers per year traffic volume, although Soyuz vehicles would need to be manufactured at a faster rate as time progressed.

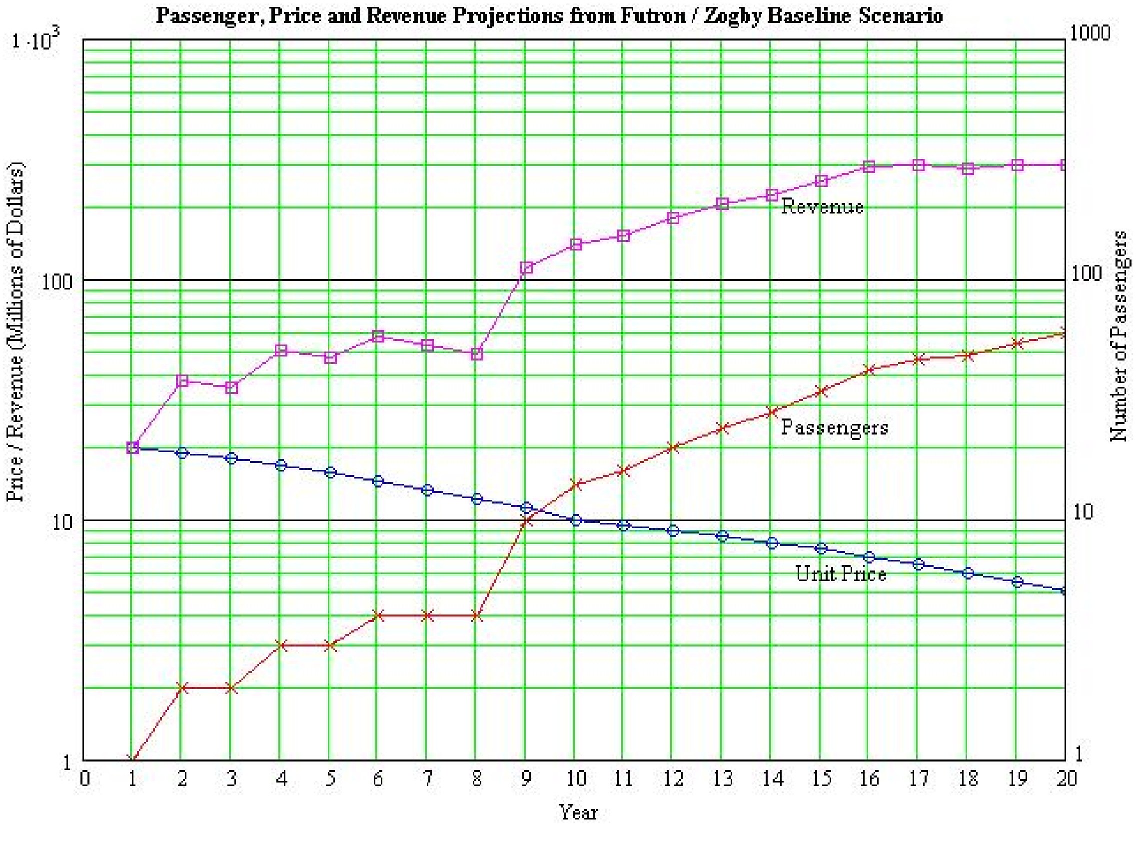


Figure 2 – The number of passengers, unit price and revenue projections from the Futron / Zogby baseline scenario. The first ten years contain regions of price inelasticity because of the small number of passengers involved and the discreet way that the number of passengers increase. In the second ten year period, while the unit price halved (went from \$10 million to \$5 million), the number of passengers roughly quadrupled (going from 14 to 60 Passengers), while the revenue (Unit Price times the Number of Passengers) doubled (going from roughly \$150 million to \$300 million).

3.2 Modeling the Government Orbital Passenger Market

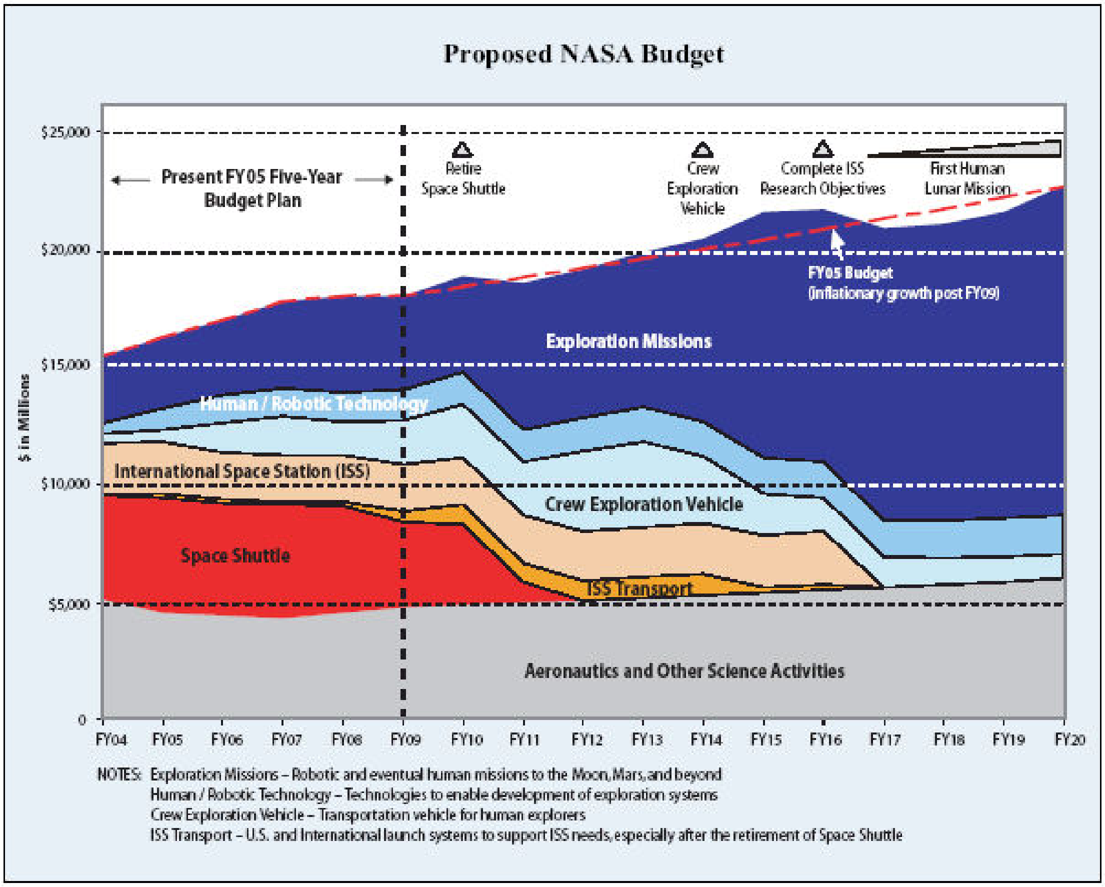
To understand the potential of the government to jump-start the space frontier if it were to buy commercial passenger service, let's now make the assumption that the government becomes a customer for flights to orbit. NASA spends roughly \$4 billion per year on the space shuttle program and an additional close to \$2 billion per year on the space station. According to the proposed NASA budget shown in Figure 3, these expenditures are slated to be reduced and then phased out while money for development of the CEV increases. Between 2014 to 2016 development of CEV is completed and it enters an operational / maintenance phase with a budget of about \$1 billion per year. Though the chart doesn't explicitly say it, that \$1 billion is probably for maintenance, refurbishment and construction of new expendable components of the system. Monies to actually operate the system probably come from the Exploration Missions portion of the budget. Thus the following scenario might be possible.

Suppose that the space shuttle budget and the later CEV budget were to be divided up as follows: \$1 billion for additional salaries, training, mission planning etc. for astronauts and \$3 billion to pay for flights aboard commercial space transportation. Assuming the starting price of \$20 million to take astronauts to orbit, 150 astronauts per year could be accommodated. If the price were to drop to \$10 million, 300 astronauts could be flown to orbit and if the price dropped further to \$5 million (the lowest price point assumed in the Futron / Zogby survey), 600 astronauts could be flown to orbit per year. The revenue stream at all three of these price points is a constant \$3 billion per year. Whereas the commercial sector only scenario ends up with a revenue stream of \$300 million per year after a period of 20 years, the government as customer scenario starts at \$3 billion per year. The 60 passengers per year reached in the commercial sector only scenario after 20 years were accommodated by expendable rocket technology. The initial 150 passengers per year in the government as customer scenario strains expendable rocket technology from the very beginning, but also provides 10 times the revenue stream from the beginning. The Demand Curve for the government as customer is obtained by setting P_0 = \$3 billion and the exponent $x = 1$ in equation (1).

In order for space transportation companies to progress to the right on the demand curve means that they must be able to provide ever lower prices for trips to orbit. This implies that the cost structures for sending people to orbit must come down which further implies that there will be multiple generations of vehicles built. Each generation requires appropriate investment with some of the greatest investments coming with the early generations of vehicles. So it is a no-brainer to assume that a \$3 billion revenue stream will have greater resources available for investment in vehicle technology than a \$300 million revenue stream.

3.3 Jump-Starting Potential of Government Buying Orbital Passenger Service

In the last ten years of the baseline study shown in Figure 2, the revenue increases from \$150 million to \$300 million (or doubles), the price goes from \$10 million per passenger to \$5 million (or halves) and the number of passengers per year goes from around 15 to 60 (or quadruples). Assuming various doubling times for revenue, there are two questions that we would like to know. 1) How long does it take the revenue in the commercial sector only scenario to come up to the \$3 billion per year that the government spends in this model? In the demand curve of Figure 1, this cross over occurs when the price per passenger is about \$150,000 and the rate of demand is about 20,000 passengers from each of the government and commercial market sectors. 2) How long does it take the cumulative revenue of the commercial sector scenario to equal the cumulative government spending at \$3 billion per year? Analyzing these questions can give us an appreciation of the potential loss of time that could ensue if the government builds its own


Proposed NASA Budget

NOTES: Exploration Missions – Robotic and eventual human missions to the Moon, Mars, and beyond
Human / Robotic Technology – Technologies to enable development of exploration systems
Crew Exploration Vehicle – Transportation vehicle for human explorers
ISS Transport – U.S. and International launch systems to support ISS needs, especially after the retirement of Space Shuttle

Figure 3 – The proposed NASA budget from fiscal year 2004 to 2020 showing the reduction and phase-out of the Space Shuttle and International Space Station and subsequent development of the Crew Exploration Vehicle to operational mode.

transportation system and doesn't support the development of an independent space transportation system. The assumption for Figure 4 is that the first ten-year period is a startup period and is not counted. At the end of the startup period, revenue is $150 million per year and the revenue doubles every doubling period. In the Futron baseline scenario, the first doubling period is ten years. Figure 4 shows the time it takes to reach the arbitrary $3 billion threshold for a number of revenue doubling periods, there being about 4.3 doublings in all cases.

The potential for very slow movement down and to the right on the Demand Curve is apparent from examining Figure 4. The revenue-doubling period of 1.5 years is equivalent to Moore's Law for microchips, which has driven the growth of computers, telecommunications and the Internet for the past several decades. Such growth is probably unrealistic for space. On the other hand, the ten year doubling period implied from the Futron / Zogby data would see revenues grow to the save level as the government spends in support of its human space program in something like 43 years. Of course, even if the government were to spend some fairly large fixed amount buying services, it would still take time to develop the technologies that could support the demand at cross over. There is no way of knowing how long that would take. The only thing we do know is that with the government as customer scenario, there are more resources available to develop these technologies. One would assume that with steady support one would arrive at the demand level and technology to support that level faster than if one relied on the slow part of the exponential growth of the commercial sector alone scenario. Such difference would constitute time lost. When one considers the cumulative effect of such lost revenues, the loss becomes even more dramatic as can be seen in Figure 5. The times it takes to reach the initial threshold of the arbitrary \$3 billion and the times it takes to reach the cumulative government spending for various revenue doubling periods are summarized in Table 1.

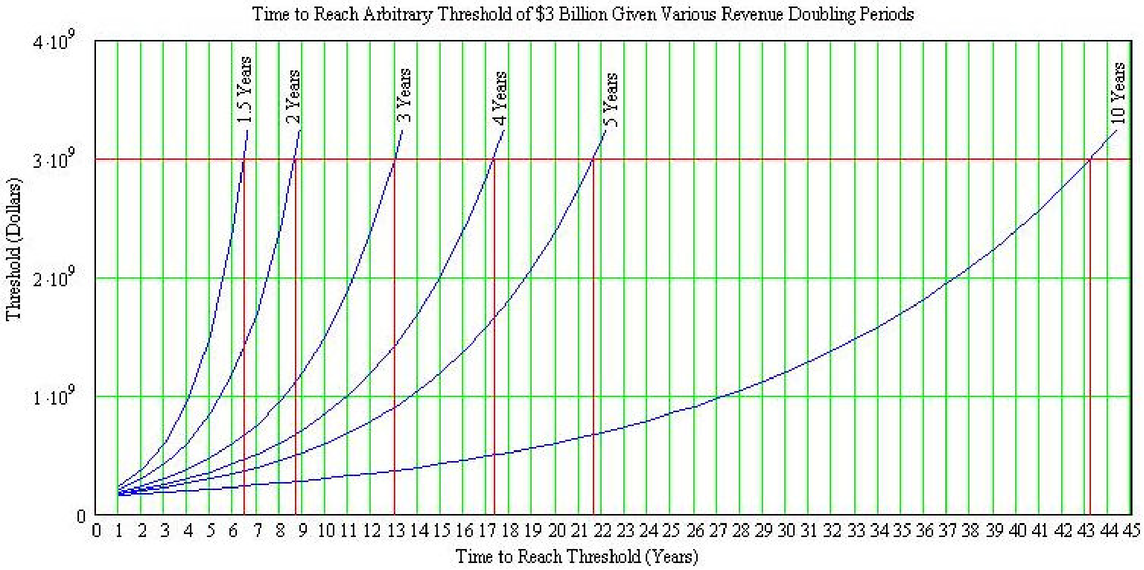


Figure 4 – The time for the commercial sector to reach an arbitrary threshold of \$3 billion assumed to be spent by the government yearly for rides into orbit, given various revenue doubling periods for the commercial sector. In Figure 1 this event occurs where the magenta colored positively sloped line labeled “Revenue – Commercial Passenger (Ideal)” intersects (crosses over) the black horizontal line labeled “Revenue – Government”. The corresponding Demand point for this revenue level is 20,000 passengers per year from each of the government and commercial sectors paying about \$150,000 per ride. The Demand Curve of Figure 1 is time independent, but assuming various doubling periods for the commercial enterprise revenue, one can estimate how long it would take to reach this threshold.

4. What to do About CEV

In the best of all possible worlds CEV would never be built. Instead the government would challenge the commercial sector to provide rides for astronauts at no more than \$20 million per ride (the alleged current commercial going price). They further would promise to spend up to \$3 billion (or some other reasonable amount) per year to take astronauts into space. Such a step would immediately create a demand for up to 150 astronaut trips into space per year. That number would initially be more capacity than any one company could provide which would, in turn, provide incentive for competition. Competition, in turn, would spur technological development to bring down costs, which would lead to reductions in prices and would lead to further demand – both from the government and from the public in general. The irony is that the time frame for the government procurement process for CEV is probably about the same time frame required by the commercial sector to produce a first generation spacecraft that can take passengers to orbit. However, it takes a leap of faith to rely upon market forces alone to produce a spacecraft.

But we don’t live in the best of all possible worlds. Instead a request for proposal (RFP) leading to a cost plus contract has been issued for CEV[6]. According to a recent issue of Space News[7], “the CEV likely will be a ballistic re-entry system that uses some combination of parachutes and retro-rockets to touch down either in the water like the Apollo capsules or on the land like the Russian-built Soyuz capsules.” One consequence of this architecture is that CEV will never take people into space in high volumes. Costs per passenger may be less than the rebuild-able Shuttle, but they will never be cheap. If cheaper commercial alternatives appear one would hope

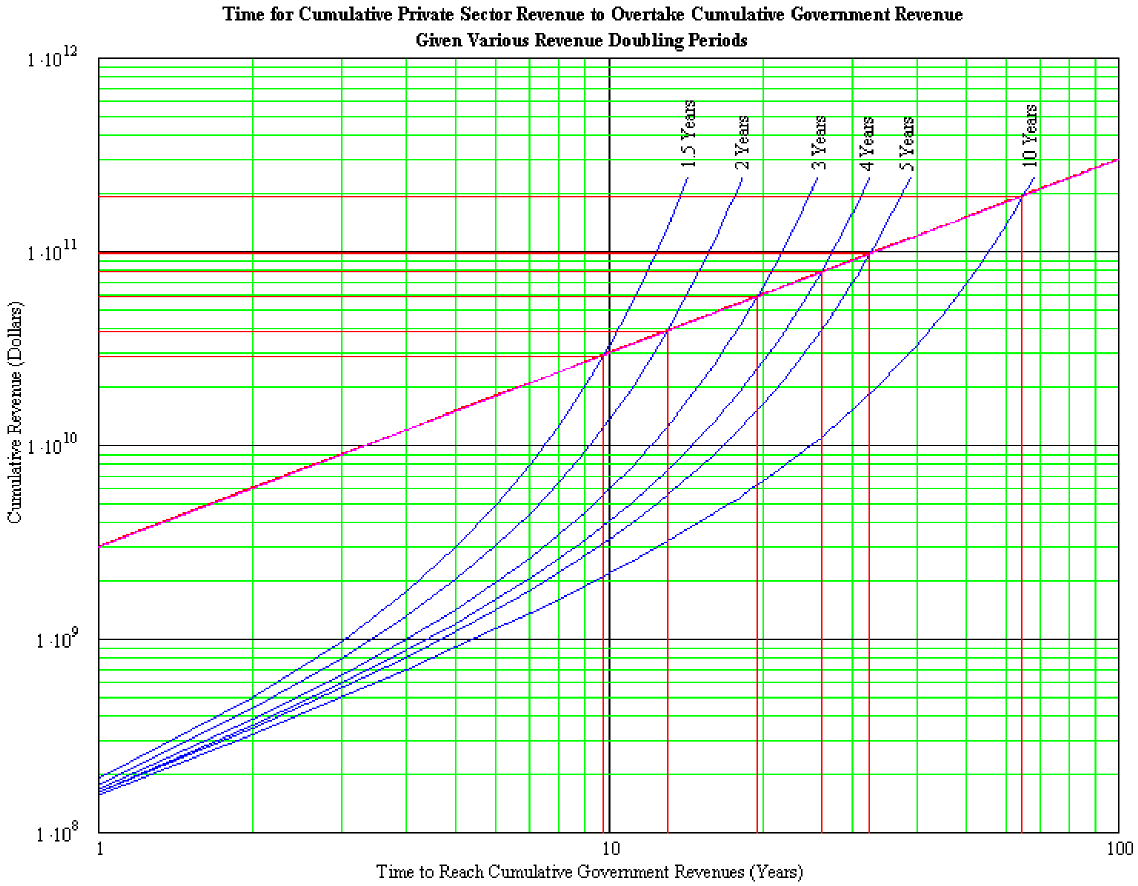


Figure 5 – Government spending for rides into space is assumed to be an arbitrary \$3 billion per year into the indefinite future. The cumulative government spending is thus the number of years of spending times this arbitrary \$3 billion per year. Revenue from commercial sector activity is assumed to double at various rates (1.5 years, 2 years, 3 years, 4 years, 5 years and 10 years). It too is accumulated over the years. At some point the accumulation of doubling commercial sector revenues overtakes the accumulation of the steady spending of the government.

Revenue Doubling Period	Time for Commercial Sector Revenue to Reach Level Government Spends Per Year (\$3 Billion)	Time for Commercial Cumulative Revenue to Reach Government Cumulative Revenue
1.5 Years	6 to 7 Years	Almost 10 Years
2 Years	8 to 9 Years	Little over 13 Years
3 Years	About 13 Years	19 to 20 Years
4 Years	17 to 18 Years	Little over 26 Years
5 Years	21 to 22 Years	32 to 33 Years
10 Years	43 to 44 Years	65 to 66 Years

Table 1 – Summary of graphs in Figures 4 and 5. The assumption of revenue doubling of 1.5 years for the commercial sector is similar to the doublings of the number of elements on a computer chip (Moore's Law), which has driven the telecommunications and computer industry and the internet. Such a rapid rate of growth is probably unrealistic for the space industry. A ten-year doubling of revenue in the commercial sector is what is implied from the second ten-year period in Figure 2 (where revenue goes from \$150 million to \$300 million). In Figure 4 it takes the commercial sector 43 to 44 years for its revenue to reach the arbitrary threshold of \$3 billion that the government is spending per year for rides into space.

that the government would switch to these instead of continuing to own and operate its own vehicles, because the government has no ability or incentive to develop markets, which is necessary to develop a strong space industry with advancing capabilities. On the other hand, will NASA become protective of its CEV portfolio and will contractors become protective of the money that CEV represents to them? Will CEV need an eventual exit strategy?

5. The Need for an Initial Jump-Start

NASA says space is difficult. We must acknowledge that getting into orbit cheaply IS difficult. The sub-orbital flight of Space Ship One was a great achievement for the entrepreneurial segment. It went over 100 km high but had no horizontal velocity needed to put it into orbit. To insert a vehicle such as Space Ship One into orbit would require approximately 35 times the energy as the sub-orbital version assuming that one could obtain this energy by increasing the exhaust velocity (the specific impulse) of the rocket engine. If we confine ourselves to chemical propulsion, where the greatest maturity exists, to obtain the necessary energy increase requires more propellant which means larger, heavier propellant tanks, a larger sized vehicle and correspondingly larger engines to drive the larger vehicle. Thus estimates of 100 or more times the energy cost to reach orbit are not unrealistic. One can achieve these energy levels by the use of expendable staged vehicles, which have fairly mature technologies (which is the direction CEV is going). However to continue to pursue expendable technology for the long run is to guarantee that the space enterprise will remain in the upper left portion of the Demand Curve. The difficulty in going to reusable technology can be gauged by contrasting the way mass is used in rockets and airplanes. The ratio of payload-mass to that of the empty vehicle is about .20 to .21 for the Delta II and abortive VentureStar single-stage-to-orbit vehicles respectively. These ratios compare not badly with the .24 typical and .30 maximum ratio of payload to empty vehicle mass of the AirBus A380. However, when comparing the propellant to empty vehicle mass, one gets ratios of 8 for the Delta II and 9.1 for the VentureStar as opposed to .72 for the A380. The ratio of propellant-mass to vehicle-mass in the rockets is 11 to 12.5 times that of the same ratio in a passenger airplane. All that mass being used to hold propellant leaves little mass left over for the things that make the vehicle safe, reliable and reusable. It's what makes rocket science, rocket science. Thus for the commercial entrepreneurial segment to move down and to the right on the Demand Curve will probably requite multiple generations of vehicles with substantial investment in each generation. So the promise of a large revenue stream that could be provided by the guarantee of a government market, would do a lot to ensure that the necessary investment to produce maintainable, reliable and reusable vehicles would take place. While the current players in the commercial entrepreneurial sector have deeper pockets than players in the past, it will still take a large effort to produce vehicles that have sufficient performance to get into orbit and can do so often, cheaply and reliably.

Vehicle	M_t = Liftoff Mass (kilograms)	M_v = Vehicle Mass (kilograms)	M_f = Fuel Mass (kilograms)	M_p = Payload Mass (to LEO) (kilograms)	M_p / M_v	$\sigma = M_f / M_v$	$\sigma_{rocket} / \sigma_{airplane}$
Delta II	231,870	25,196	201,703	4,971	.197	8.01	11.1
VentureStar	991,383	96,145	874,830	20,408	.212	9.1	12.6
A380	Max: 560,000	276,800	Max: 199,000	Typical: 66,400 Max: 84,200 (Not to LEO)	Typical: .240 Max: .304	0.72	----

Table 2 – Comparisons of mass and mass ratios between rockets and airplanes. Compared to airplanes, chemically fueled rockets are flying gas tanks, with all that that metaphor implies.

6. Too Much of a Good Thing?

So far in this discussion the presumption has been that the government as buyer of commercial orbital passenger services is a good thing. The government support provides extra demand, which leads to needed revenues so that technological hurdles such as reusability and larger scale can be broached. Without government support the commercial sector would have to go through a long growing phase before there would be enough demand to even warrant investment in larger scaled spacecraft, let alone reusable technologies. But could there be too much government support? In the model, the government support level was arbitrarily set at $3 billion per year. This value was arrived at through some reasoning about how much is spent on the space shuttle per year. But during the period of time when the government dominates the market, the demand curve is only slightly elastic (go back to Figure 1). Could too much support cause the companies playing in the orbital passenger arena to become complacent and flabby? Lack of sufficient elasticity means that the motivation of increased revenues with reduction of prices is not as strong. At $3 billion per year the cross over point between government domination to commercial passenger domination occurs when there are 20,000 passengers from each of the government and commercial passenger segments paying about $150,000 ticket prices. Yes, 40,000 passengers per year definitely encourages the development of both larger scaled spacecraft and reusability. But it's a bit of overkill. At $1 billion per year, the cross over point occurs when there are 2000 passengers per year from each of the government and commercial segments paying $500,000 ticket prices. The demand of 4000 passengers per year could be accommodated by 400 flights of 10 passengers each, 200 flights of 20 passengers each, 100 flights of 40 passengers each and so forth and so on. There is sufficient demand to exercise both scalability and reusability and yet the market is being distorted for a much smaller part of the demand curve and surely for a much shorter duration of time. As for the initial impact of a $1 billion subsidy, at a starting price of $20 million per passenger, there would still be demand for up to 50 passengers per year (from the government market) starting from the first year. This figure still compares favorably with the 60 passengers per year obtained, in the Futron / Zogby baseline scenario (commercial market), after 20 years.

Could the jump-start be reduced even more? The lowering of the cross over point between government and commercial domination of the space passenger market needs to be balanced with the need to produce enough demand up front to motivate investment in cost reduction technologies. Without such a jump-start, if the assumptions of the Futron "Space Tourism Market Study" are reasonable, there could be more than one, possibly two, maybe even parts of three decades before there is sufficient market demand to warrant investment in the types of cost reduction technologies that will make opening the space frontier possible. The new path that NASA is taking is not helping the situation. The CEV, that NASA is having built, takes inspiration from the Apollo era. Funding for technology, like X-43, which could have been useful for reducing the cost of space passenger access, has been reduced or eliminated. A jump-start of the only space market that has the inherent incentives to motivate these investments is an imperative.

7. Conclusions

So what would be the consequences of the government buying passenger service to space? And how would these consequences contrast with the strategy of business as usual where the government owns and operates its own vehicles? It is important to realize that the human-passengers-to-space market is going to be the driver for improvements to space access technology. The people-to-space market is elastic over many orders of magnitude of unit price, meaning that revenues will increase as unit prices go down. This elasticity provides an intrinsic motivation to go to successive generations of launch technology in order to reduce cost structure and thus be able to offer lower unit prices and thus increase revenue. By way of contrast, the cargo and freight markets are typically not elastic. Large growth in these markets depends upon the people-to-space market – the more people sent into space, the greater the need for freight and cargo – and not the other way around. A strategy where the government provides opportunities to the commercial sector to only launch freight and cargo but keeps humans-to-space under the purview of the government is also business as usual. Thus a business as usual strategy keeps the government's hands metaphorically on the throttle, allowing only a small rate of growth.

One might respond that certainly if the commercial sector produced a vehicle that could take people to space cheaper than a government owed vehicle, and with reasonable safety, then the government would switch to buying rides on the commercial sector vehicle. Such would be a rational belief, but would it necessarily be true? Government programs, once started obtain a life of their own. The space shuttle program when it terminates in 2010 will have been operationally in existence for 29 years. If the development phase is included, well over thirty years. And if the Columbia accident had not occurred, the space shuttle program probably could have gone on well past the year 2020. As the new space passenger providers start to come online with orbital service and start providing capability comparable with CEV, will voices from within NASA accuse them of having unsafe and "gimmicky" technology? Even if it were true that the government would buy cheaper commercial passenger services, if available, it begs the issue of time lost while the commercial sector grows sufficient demand to warrant investment in technologies that will significantly reduce cost structure. On the other hand, the 2006 NASA budget stipulates that NASA intends to meet the need of providing human-rated crew transport as well as cargo transport to and from the space station by purchasing such services from foreign providers or domestic commercial providers[8]. So maybe there is hope. And if NASA reverts to the way it has behaved in the past will CEV need an Exit Strategy?

Technologically, the initial vehicles produced by the commercial sector may not be that much different from those produced by the government. However, the development pathways are completely different. The promise of a government market, would encourage many players, large and small, to participate. Competition in the entrepreneurial commercial sector would encourage development of different technologies in parallel. According to the commission report – "It is estimated that over $400 million has been invested in developing technology by the X-Prize competitors that will vie for a $10 million prize – a 40 to 1 payoff for technology". Imagine how much would be invested in technology if the government spent a steady sum of money buying rides into space instead of building their own spaceships. However there is a danger of the government perturbing the market too much if that sum were too high.

With a business as usual strategy the government invests in a single technology that looks very much like it came from the Apollo era. Without government support, the commercial entrepreneurial sector still develops, drawn on by the possibilities of space tourism. But without the extra monies implied by the government market, the commercial sector will necessarily develop at a slower pace. So the value of the government buying commercial orbital passenger services is the value of time saved because the commercial sector has sufficient demand and resources to invest in the technologies necessary to reduce cost structures. It's not a question of if the government will eventually buy rides into space. It's a question of when and under what circumstances. Given that commercial capabilities to take human passengers into space do not currently exist, the strategy that will probably unfold will be some combination of business as usual and the government purchase of passenger service. The ideal level of government purchase of passenger service is such as to create sufficient demand to motivate investment in technologies that will bring down cost structure but not so much as to perturb the market to any great extent and for any great length of time. An enlightened government policy could jump-start the space frontier.

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