The Eighties

Reading
1. Chap. 5 and 6, Spaceflight and the myth of Presidential Leadership."
2. Chap. 2, "Space Policy: How Technology, Economics and Public Policy Intersect."
3. Chap. 5 and 6, "Beyond Horizons."

Strategic Themes

1. The Shuttle policy – Shuttle or nothing and the consequences of this choice
2. The return of the technocratic approach on Station SDI, NASP and SEI; secondary vs. primary policy
3. The choice for a Space Station - camels nose under the tent?
4. The choice for SDI – technically impossible
5. The Challenger disaster (and other launch failures), consequences and the changes to space policy.
6. The Landsat experience and commercial space act as an experiment in commercialization
7. The choice for a Space Exploration Initiative – back to the Moon and onward to Mars!

In 1977, NASA projected that the shuttle would fly 600 times in the first eleven years of operation. The failure rate was estimated at 1 in 10,000 flights and the reliability (i.e. ability to take off on time) was estimated at 98%. The total cost of developing the shuttle in 1972 was estimated at $8 billion with each new orbiter costing $250 million to build. The first test flight was scheduled for early 1978. The Shuttle was designed to DOD requirements to place reconnaissance satellites in orbit and retrieve them. Thus both it's size and cross range flowed from the intelligence requirements. The facts were very different. The first shuttle flew on April 12, 1981, three years late mainly due to the technical requirements and difficulties associated with the Space Shuttle main engine. It cost $12.6 billion to develop and each orbiter cost almost a billion to produce. The cost per payload pound is over $10,000. In the years 1983-1994, it only flew seventy times and this last year (1999) only managed three flights. Far from having a failure rate of 1 in 10,000 it proved (unhappily) to have a failure rate closer to 1 in 25. Interestingly this is very close to the historic failure rate for solid rockets. Its ability to take off on time has proven to be about 50%. The STS was supposed to be frequent, cheap and manned. Instead, its is occasional, expensive and manned. How could it have gone so wrong?

A fundamental difference with the Apollo experience is in the space policy which drove the Shuttle. Apollo had a clear simple goal, man on the moon within the decade. In contrast, the STS was all things to all people. It was initially conceived by NASA as the "truck" which would carry humans and material to an Earth orbiting space station. It was also sold as the nation's primary launch system for all payloads, large and small. It was supposed to use the economics of reusability and be cheaper to fly than any existing or future expendable launch vehicle. It was to provide routine and frequent access to space. It was also to provide and carry orbiting lab facilities until a space station could be built. These were captured in the Reagan space policy of July 4, 1982 which defined the STS as the primary space launch system and said that it would be both fully operational and cost effective in providing routine access to space. The president also

believed strongly in the commercialization of space, a policy that he tried with Landsat and foisted on the STS and NASA.

Since NASA wanted the STS to be primary US launch vehicle and wanted to justify the projected high flight rate it had to capture most of the launch market. Thus it got the Air Force to agree that all future military missiles would fly on the shuttle. The Air Force also agreed to refurbish the old MOL Space Launch Complex at Vandenburg to have a site to launch into polar orbit from military missions. It of course required that all NASA payloads went on the shuttle. Thus the Hubble and Galileo were designed to go up on the Shuttle. It enticed the commercial customers in two ways. It offered very attractive prices for the first three years of Shuttle operations. Thus a PAM-D class satellite launch could be had for $15 million whereas to get the same launch in an Ariane was $30 million and $25 million on Delta. It also pulled it's payloads from Delta and Atlas. Since there were now being used less and less but they needed to sustain their infrastructure, their launch costs rose. Thus Delta cost rose from $5 million a launch in 1970 to $26 million a launch by 1980. NASA also terminated the Delta and Atlas production lines in 1985. The Air Force did buy some Titan 34D's and contracted to buy only a few Titan 4's but did so over the objections of NASA and agreed to stop doing this. Thus NASA and the government moved to a one launcher policy driven by the desire for cost effectiveness. By January 1986, the STS had only flown twenty four times and had proven to be neither cheap nor reliable. However, so committed was NASA to the thesis that this was an operational vehicle that after only four test flights they had declared it an operational vehicle and on the 25th flight they were going to fly a teacher into space, an event to be watched by millions of schoolchildren. Instead of quick turnaround what they had found with this "operational" vehicle was that every one of the 17,000 tiles on it needed to be inspected after every flight and every SSME needed to be replaced every time. They had also noticed some worrisome erosion in the solid rocket joints where the segments were put together. Thus each Shuttle, instead of a turnaround of days, took months to prepare and required a large standing army of people to maintain it at human flight safety levels (0.99999). How could the 1977 estimates have been so wrong?

In retrospect, there were a number of factors. There was a deliberate NASA strategy of getting support for large programs with optimistic operational estimates and low cost estimates. This is the well known Camel's nose under the test strategy which basically relies on getting things going and building supporters who would sustain the program as the costs mounted. This strategy would be very clear on Station. In addition, the designers were overly optimistic about the technical process of NASA. Perhaps they were still living in the glory days of Apollo. In any case they clearly underestimated the SSME difficulty. Still they seemed to have taken leave of common sense. The SSME is operated at 109% of total rated thrust. This is at the "red line". Any mechanic will tell you that an engine routinely operated at the "red line" will break down frequently. Truck engines (the model for the STS) work so reliably because they operate far from the maximum capabilities of the engine. The STS was certified as operational after only 4 flights with the really flight critical part the ascent, being only 8 minutes each. Thus it was certified after 32 minutes of critical flight. In contrast the F-22 is required to be tested for a minimum of 183 hours of flight time before Congress authorizes buying the aircraft. Finally, the historical probability, based on many launchs, of solid rocket failure has been 1 out of 25. How the NASA engineers managed to convince themselves that the catastrophic failure rate would be 1 in 10,000 when the STS had

solid rockets on it, is hard to rationalize. In retrospect it is clear this was a disaster waiting to happen.

On 28 January, 1986 the Challenger took off with a teacher on board and exploded 73 seconds later. The immediate cause of the explosion was a burn through of one of the O-rings on one of the solid rocket boosters causing the shuttle Challenger to be ripped apart at altitude. In the investigation that followed a number of contributing factors were identified. First, NASA managers under pressure to show the STS was reliable had authorized a launch even though the temperature criteria were outside of the known operational range of the STS. In a sense the operational mindset had overtaken them. They overruled the engineers who warned of possible danger. Second, NASA engineers had known for some time that there were problems with gas blowby through the O-rings. However, the NASA system ignored these signs and did not calculate the consequences of a blowby. Third, the NASA communication system by this time was so poor that senior managers did not know of these potential issues and the NASA administrator for the first time ever did not go to the Cape for the launch. Thus the R&D agency which had done Apollo in a few short years was reduced to an operational agency which could not even do this job well.

The Challenger disaster struck the national psyche like Sputnik. It was made all the more visible by the fact that so many school children were watching. It plunged the space program and space policy into a huge crisis. Unhappily, there were several other launch failures that occurred at about the same time. These included in April 1986, a Titan 34D at Vandenberg and in May, a NASA Delta rocket that was launched into a thunderstorm. Could NASA do nothing right! The result was that all launch activity was grounded for several years while the technical issues were fixed & while the space policy was adjusted. The consequences of putting all the nation's eggs in only one major basket now meant that the US had no reliable means to get to space. The STS was grounded for 31 months and in that time space policy was transformed and the Air Force, commercial, international and NASA communities repositioned themselves. Since no launches were available on US rockets, many commercial satellite contractors turned to Arianespace. The US market shares of commercial launch plummeted and Ariane took significantly more than 50% of the free world market. In a sense, the space policy of not allowing the French to use American rockets which pushed them to develop their own and putting all the US eggs in the Shuttle basket led directly to Ariane capturing most of the commercial market. Fortunately, many satellites had been designed to fly on the Shuttle and on the Ariane. After much debate in the space policy community, it was decided that the Shuttle would only be used for national security missions and for scientific missions where human presence was essential. All commercial communication satellites were pushed off the Shuttle and told to find other rides. This caused chaos in the commercial community and pushed them into the arms of Ariane. Of course this policy of using the Shuttle only when essential is a testament to the fact that it will never be an economic proposition. The DOD decided that it wanted to move away from the Shuttle and return to a mixed fleet of ELV's for assured access to space. Thus it cancelled the development of SLC6 at Vandenberg and restarted the Delta, Centaur and Titan lines. It agreed to buy 20 Deltas, 11 Centaurs and 24 Titans as a deliberate attempt by government policy to kickstart a dying industry. It also agreed to provide range support for all launches at the ETR and WTR for only direct costs. Thus the DoD deliberately agreed to subsidize the commercial space industry.

The NASA scientific satellites were shelved to await the STS return to flights. Thus both Hubble and Galileo were put in storage to await later launch. In addition, the cryogenic Centaur upper stage for use from the Shuttle bay was cancelled. It was now seen as just too dangerous for a rare, high value asset like Shuttle. The direct consequence of this was that the Galileo mission when it flew would take two more years since there was now no upper stage to push it directly to Jupiter. In order to get these it would have to do a flyby past Venue and the Earth twice to get enough delta-v. Since it is an RTG powered vehicle, this meant that 30 kg of plutonium came flying by the Earth twice to get to Jupiter. This has had the consequence of inflaming the anti-nuclear movement and eventually sealed the fate of nuclear power in space. The delays for Galileo and the Hubble turned out to have interesting consequences. For Hubble, it was fortunate since problems were discovered with the HST paint that would have been much harder to fix in orbit and may have limited its utility. For Galileo, it was bad. Galileo was shipped across the country three times (twice to the Cape and once back). This cross country trip and long storage led to the loss of lubricant in the high gain antenna which subsequently led to loss of that system on the way to Jupiter. Finally, NASA abandoned the policy of flying civilians (i.e. not regular astronauts) in the shuttle. In 1991, the President's advisory commission on space found the STS was still in the developmental phase. So much for operational status!

For space enthusiasts, the Reagan and Bush administration seemed like a return to the Kennedy mindset. Both President's believed in big government initiatives which they announced. This was a return to the technocratic approach. However, there was a big difference relative to the Kennedy years. In all cases they chose targets that were too hard to do in a small number of years and they did not get or achieve the support of Congress in their decisions. Perhaps this is because they were not willing to make these primary policy issues versus ancilliary policy issues. Thus in 1983, President Reagan committed the country to a Strategic Defense Initiative to provide an impenetrable shield against Soviet missile attack. In 1984 he pledged support for the NASA goal of a permanently manned space station in a decade and also an "Orient Express" hypersonic aircraft to reach the far East in hours. In 1989, President Bush pledged the country to establish a lunar base and organize a human expedition to Mars within 30 years. All of these bold initiatives have failed. The reason for this are many but essentially come to issues of technical capability and primary policy versus secondary policy. Let us deal with technical capability first. The SDI, NASP and SEI as conceived either were technically almost impossible or involved basic research issues that had not been resolved. Basic research issues tend not to be solved by money but rely much more on getting the best and brightest minds to work on them. In the language of technology planners these things are idea limited rather than funding limited. For SDI, the conception of a perfect defense against a 10000 warhead attack when even one warhead can kill a city involves levels of reliability unheard of in modern engineering. This is especially true since there would be no opportunity for a real test under real conditions of the integration of all the hardware and software to get a perfect kill ratio. No weapons planner plays on a kill probability of 1 but that is what the requirement for the system was. From the record, it seems like President Reagan was persuaded by a few influential hawks and it fit nicely with his vision of America. Even his own science advisor was not told about his decision for SDI. This was a far cry from the Kennedy days. For the Orient Express (aka NASP) there were fundamental flaws in the requirements. It was meant to get to the Orient quickly but also to deliver things to orbit. These requirements meant that it had to fly fast in the dense atmosphere. This led to demands on materials and our breathing engines that (still) require basic research to resolve. When NASP

started it was said one needed to work on materials and engines when it collapsed $9 billion later, it needed work on materials and engines. For SEI, there are basic research questions of human survival under high radiation, microgravity environments for long times that we do not understand.

In contrast the Apollo program had no fundamental research questions we did not know. To see the contrast it is helpful to consider two other programs which have not yielded to big government pushes but instead have required steady pushes over long times to see progress. These are the war on cancer (born of the Apollo effort…if we can go to the Moon we can solve cancer) and the effort to harness magnetic fusion energy. Both of these big pushes have failed dramatically. Another key part of the Apollo program was that it attracted and motivated a generation of the best students. By contrast, the SDI initiative was so controversial that many of the best scientists would not i.e. refused to work on it. This led to the statement from the SDI chief scientist that if he could not get a few first rate scientists to work on something, he would make it up with twice as many second rate scientists. This of course is a linear view of progress in basic research that is not supported by the historical data on how progress is made in science.

The second reason for failure is in primary versus secondary policy. Primary policy breaks with past decisions and perspectives to meet the nation's top priorities. It has long term goals and has organized efforts to achieve them, so for Reagan primary policy was budget cuts, tax cuts and a huge defense buildup. For Bush primary policy was on the budget deficits. Primary policy is innovation. By contrast ancillary policy does not solve identified national problems. It has low grade status and receives limited attention and funding. Ancillary policy is the policy of continuation. By all these measures, in the 60's space policy was primary policy. It met the national angst after Sputnik and was bold and innovative. The Congress clearly bought in and money flowed freely. There was broad public support and consensus on the goal, which was to show we could beat the Soviets. In contrast all the space policy behind all the initiatives was secondary or ancillary policy. The interest in the space enterprise had declined in the public mind and there was no consensus between the White House and the Congress on where to go. There was no Johnson to build the consensus with the Congress. In primary policy the question is "What should we do?" In ancillary policy, the question becomes "What can we afford?" and "How can we sell it?" The Space Station decision was marked by all of these large differences with the Apollo decision. The biggest and clearest way to see the difference between the two is to look at the difference in funding as a function of the Federal budget. This is a measure of the importance the administration and Congress really puts on something. In FY60, the NASA budget was 0.8% of the Federal budget. In FY66 it was 4.4% of the Federal budget, in FY80 it was back to 0.8% of the budget, in FY84 (Space Station) it was 0.8% of the budget and actually dropped the next year to 0.7% of the budget. FY90 (SEI) it was 0.99% of the budget and has since dropped significantly.

The Space Station was announced in January 1984 by the President in the context of a speech where he talked of living and working in space for peaceful economic and scientific gain. However, just to contrast it with the Soviet Mir (peace) it was to be called Freedom. What was the objective of the station? In the original NASA plan, the Space Station was a staging place for a mission to Mars serviced and supported by a truck, the STS. Thus NASA touted Station as the next logical step but since there was no national commitment to Mars, there was not any real

debate on what it was the next logical step for. Clearly also a staging post is different than a scientific facility and has different design drivers. Nevertheless because there was no clear objective for Station it quickly ran into trouble and NASA made it worse by repeatedly changing the rationale for the Station. Thus is was the next logical step, for a while it was an orbiting lab facility to do all kinds of science work, sort of a Oak Ridge National Lab, in the sky. This ran afoul of a number of the scientific societies who pointed out that most science does not require it to be done in space (and of course they were concerned that it would take money from science). It was also touted as an international effort to show how the US got along with the Europeans and Japanese. Both of these space agencies were strong armed into participating in it. For a while it was also a place where commercialization of space would be undertaken. These were claims of vast amounts of commercial discoveries that would flow from Station. When asked to be specific the advocates of this would suggest that it was serendipity and one could not say exactly. Finally in a low point, the Station was pitched by one NASA administrator as a means to revitalize the education of youth in America. Of course this raised the question that if this was the primary objective why not spend the money directly on education?

NASA also suggested the station cost as $8 billion. This estimate came not from any technical cost analysis (actually the internal cost estimates at NASA were twice this) but from the political perception that $8 billion was the most they could ask for and get the project approved. This was the camels nose strategy in full force. In order to come up with even the $16 billion figure, NASA omitted all transportation and operations costs for the station. In contrast the estimated cost of Station is $19-22 billion to construct and $96 billion for all costs over its full projected lifetime. This lack of consensus over objectives led to the predictable result that the station had a major redesign or rescoping in 1986, 1988, 1990, and 1992. By the time the decade was up (in 1994) NASA had spent $9 billion and had not produced a single piece of hardware. NASA also decided to go without a prime contractor for the Station and allowed it to become a jobs program in as many states as possible. The NASA centers saw the station as the way to build up their own institutional power and each brought as much of it to their centers as possible. To give a sense of the forces by the early nineties to run the centers took $9 billion/yr. without doing anything productive. Thus the Station became just a means to justify the continued existence of NASA and spent most of the eighties being redesigned to meet changing objectives. It came up repeatedly in Congress for approval and was nearly killed on several occasions. Only its use as a job program saved it. What a far cry from the vitality of the Apollo program.

For Military space, the eighties were a period of considerable opportunities and maturing. Within the DoD, the Air Force formed a Space Command in 1982 and 1985 a Unified Space Command was formed. This was an attempt to “operationalize” space and make it a mission rather than a place. In the meantime the systems like DMSP, DSP, Milstar and GPS continued to come online and provide space support that would come to fruition in the Gulf War. The big military innovation in space was the SDI. Once it was announced, large resources flowed into it. Many old and new ideas were discussed to meet the objective of an impenetrable shield. These included nuclear explosion driven X-ray lasers to shoot down missiles, large space based lasers, particle beam weapons and by the end of this period ‘Brilliant Eyes” and “Brilliant Pebbles” as technical schemes to hit all 10,000 warheads. During this decade there was two attempts to undertake space commercialization that collapsed under their own logical contradictions. One was the Commercial Space Launch Act of 1984 which directed the DoT to facilitate, license and

regulate a new launch vehicle industry in ELVs. NASA allowed Delta, Centaur and Titan to continue production at their risk to serve the private market. Unhappily this was undercut at exactly this time by the predatory pricing policies of NASA on the Shuttle. No commercial company could compete and the production lines went down in 1984. The White House policy of space commercialization was undercut by the contradiction of having the government offer subsidized rides to space. The other attempt was the attempt to commercialize Landsat. Landsat is an Earth observing system of 25m resolution in panchromatic mode. In 1983, the administration wanted to commercialize this and had Congress pass the Landsat Sensing Act of 1984 to turn it over to the private sector. However, only one firm bid for it, a joint venture of RCA and Hughes. With no competition, they got to get the spacecraft free, the right to sell the data at prices they were free to set and money to cover operating costs. There was no incentive for them to invest. When the Congress subsequently refused to provide follow up money for new Landsats and they raised prices ten fold, then the stage was set for disaster. Eventually, the company stopped offering service and the Congress took back the spacecraft. Basically there was no market for the public good that the data represented. The decade ended well from the point of space enthusiasts. President Bush announced the SEI in 1989 and it looked like once again the nation was committing itself to an Apollo like venture!

Space Policy discussion

The President is contemplating the idea of a Space Station as an announcement in his upcoming State of the Union message. Should he announce this or should he think of some other large initiative (the Super Conducting Super Collider, for example)

Break up into groups with each group representing an agency position (DoD, NASA, OSTP, the Congress, Scientific societies etc). Articulate to the class the choice the President should make. You should couch your response in terms of the known intent of the president which is to show the weakness of the Soviet system (who have a space station) and to show that America is great again!