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Paper Session I-C - Missiles, Mythologies and Misses: A Perspective on U.S. Space Launch Developments

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Paper Session: II.C. Beyond 2000
By Wayne Eleazer

The history of the American space launch program has been one of both successes and failures, but in many respects has been characterized and guided as much by questionable assumptions and "mythologies" as it has by planned technological achievement and careful program management. Ironically, while launching satellites is considered to be the pinnacle of "hard" science and the ultimate in systems management, the way in which space booster development has proceeded has been anything but scientific, with few management principles of any kind discernible. That tradition continues to this day.

The First Launch System

The first dedicated U.S. space launch program was Vanguard, begun in 1955. Although for the previous ten years the U.S. military had underway ballistic missile development programs, these were deliberately ignored under the belief that such weapons programs should be kept separate from purely scientific efforts. This was the first space launch mythology: the Vanguard Mythology. It stated that military programs somehow tainted scientific efforts and should be kept separate. Its immediate result was the assumption that military development experiences could be ignored. Ironically, Vanguard ultimately became a U.S. Navy program, an approach which not only violated the principle of separation but also denied it the experience gained in the Army and Air Force programs. But coincidentally, the approach did result in the three major U.S. military services each having their own space program.

Vanguard was a spectacular failure, and at a very bad time. No one had told the Soviets of the mythology surrounding Vanguard, and unencumbered by such thinking they proceeded to launch the world’s first artificial satellite utilizing the same SS-6 Sapwood missile they were building to threaten the United States. In response, the Vanguard mythology was thrown away overnight and Werner Von Braun’s U.S. Army ballistic missile team was given the go-ahead to enter the realm of “scientific research” space launch. A derivative of the Army Redstone ballistic missile (what we would now term a “theater” weapon) the Jupiter C launch vehicle, was used to place America’s first satellite, Explorer 1, into orbit on 31 January 1958. From that point on, it became obvious that developments of military missiles were the most expeditious way to meet most space launch requirements, thus establishing an approach which has continued for over 40 years. The first space launch mythology had been overcome by practical considerations.

Ironically, the Army’s team led the way, but Air Force ballistic missile systems became the basis for most U.S. space launch systems. There were various reasons for the Air Force dominance, but one of the most important was the ancestry and operational concept of the Army systems. The Army missiles were direct descents of the WW II V-2 missile, and like their German ancestor, were designed to be transportable and fired from relatively simple field sites. This was of great utility in combat (as the Air Force found out in dealing with another V-2 descendent, the Scud), but it made the Army missiles heavier and less efficient than the Air Force systems which were mean to be launched from fixed installations. But even with the success of the military-derived launch vehicles, (indeed, because of the success) a new mythology was formed.

Missile Technology, Whether You Need It Or Not
Missile systems had to advance as weapons systems in order to meet new challenges imposed by the Soviet threat. More American ICBMs had to be deployed to counter increasing Soviet strategic missile forces, and that in turn emphasized the need for U.S. missiles to be operable simply and at low cost. The increasing numbers and accuracy of Soviet missiles meant that U.S. missiles had to be more survivable, which required the ability to launch from an underground silo as well as the use of more robust flight hardware. A related factor was the combined advancements in the design of re-entry vehicles and nuclear weapons enabled missiles to be made smaller, which reduced the emphasis on throw weight and therefore reduced demands for propulsion system performance.

The net result was a technological focus away from the needs of launch vehicles. Storable hypergolic rocket propellants were much better than liquid oxygen and kerosene for missile systems, but also were much more expensive, far more hazardous, and produced significantly lower performance. The inertial guidance systems used on the later missiles were far superior for weapons systems to the radio guidance used on early ICBM's purposes, but also cost far more and were somewhat less reliable. For ballistic missiles, solid rocket motors provide faster reaction time, lower operating costs, and less vulnerability than liquid engines, but also have lower performance and are essentially impossible to test before flight. Despite the obvious disadvantages, the use of the new missile technology for space launch purposes was accepted and encouraged. Cost was one reason; the missile technology was "free" to the space launch industry. Even more importantly, for the most part, the same people were involved in the design of the replacement missile systems as were charged with handling space launch needs. The prevailing attitude asserted that later designs were intrinsically superior to older hardware, and the applicability of the technology really didn't matter. Better was indeed the enemy of good! A new mythology, which urged that missile advancements (and disadvantages) be carried over to launch vehicles, ruled the day. Except for some upper stages, very few space launch developments were pursued, and for the most part ballistic missile requirements defined space launch capabilities.

For their part, the Soviets ignored the Missile Mythology and continued to develop new dedicated space boosters vastly different from the ballistic missiles they deployed in even larger numbers than the U.S. They also continued to utilize their space booster derivatives of the SS-6, a rocket which had more in common with the V-2 technology than any U.S. system. Soviet propulsion system research and development continued, unabated by the parallel developments in missile research.

The one noteworthy exception to the Missile Mythology was the Saturn series of boosters. Designed by the Von Braun team, the Saturn series was focused toward one end: manned moon missions. In the end it accomplished its objective supremely well, but unfortunately yielded few advancements that were applicable to the Nation’s overall space launch needs. Once the Apollo program ended, so did the requirement for the Saturn series. Ironically, some of the most useful launch developments of the 1960’s came not from the actual manned program, but from its supporting unmanned elements. For example, the premier upper stage engine in use today, the Pratt and Whitney RL-10, was developed to place the unmanned Surveyor spacecraft on the Moon. The rocket motors developed for Surveyor's descent stage formed the technological basis for most solid propellant upper stages. In contrast, none of the Saturn propulsion systems is in use today.

By the late 1960's the deficiencies in the Missile Mythology approach had become obvious. Space boosters clearly had requirements entirely separate in nature from those of the newer ballistic missiles, and continuing the use of early ballistic
Pretty Big But Not So Dumb

The Big Dumb Booster concept was borne of the realization that the Missile Technology Mythology was not yielding the most cost effective and reliable launch vehicles. Big Dumb Booster proponents focused on the idea that certain booster components could be built relatively cheaply, not push the state of the art in terms of performance, and still meet requirements. For example, the weight of first stage hardware has a relatively small impact on the system's total performance, but can have large effect on cost if every effort is made to pare every unneeded ounce. One of the first steps toward implementing the Big Dumb Booster idea was a rocket engine built in a shipyard by commercial practices rather than aerospace standards. The engine was no masterpiece of lightweight engineering, but it was both robust and remarkably inexpensive.

The "dumb" element of Big Dumb Booster was probably based on the recognition that upper stages as well as the spacecraft they carried incorporated their own inertial guidance systems; with proper software and interfaces these could guide the lower stages during ascent. While it increases the complexity of integrating the flight vehicle, such an approach could lower costs by the elimination of unneeded, highly expensive hardware. The dumb booster approach was used on a large number of Air Force Thor missions with a fair degree of success.

Big Dumb Booster seemed to be practical and appeared to be promising, but before it really got started it was pushed out of the way by a new mythology.

But It's Gotta Be Manned

As the Apollo program reached its ultimate goal with the flight of Apollo 11 in July 1969, there was a recognition in some circles that it also meant the end of the only established justification for the manned space program. The manned program had been focused on getting to the Moon. The only other well developed justification for manned missions, Earth observation, had been found to be better performed by automatic systems. The solution that was developed was to tie the requirements that needed nor justification to the manned program. The Space Shuttle program was born, and with it, the Manned Mythology.

The Manned Mythology asserted that the payloads to meet scientific civil, military and commercial requirements could best be hauled into orbit by a reusable launch vehicle. And by placing a crew aboard that vehicle, a manned program could be had "for free", piggybacking on the established need for the unmanned payloads. To a large extent, the needs of the unmanned and manned were compromised by one another. Space Shuttle payloads had to meet the strict requirements of the manned system, but
in order to meet the payload's requirements the manned system was the first which could conduct no new exploration.

The Manned Mythology essentially stopped all space booster development in the U.S. for a period of almost twenty-five years. The only significant work done during the period was merely additional adaptation and modification of the existing ICBM-based boosters. A few small private firms tried to develop their own boosters in the late 1980's, but were not very successful. The Air Force finally received approval to develop the Titan IV, but it was merely "complementary" to the Space Shuttle, and in any case was a minimum modification version of the earlier Titan IIIE, which was in turn a combination of 1960's Titan and Centaur technology.

Following the Challenger mishap in January 1986, U.S. policy changed radically, but was still based on use of the same vehicles which Big Dumb Booster was intended to replace in the late 1960's. The results of the Missile Mythology once more were felt, and its shortcoming once more became apparent.

A New Approach

Even as work went on to restart closed production lines and recover U.S. space launch capabilities in the late 1980's, the Air Force and NASA struggled with the best way out of both the missile and manned mythologies. The result was two abortive, joint programs, the Advanced Launch System (ALS) and the National Launch System (NLS). To a degree, ALS and NLS embraced the Big Dumb Booster concept in that most of the emphasis would be on low manufacturing cost rather than high performance. Where Big Dumb Booster had tried shipyard manufacturing techniques, the two later programs took inspiration from the automotive industry. Both programs were canceled due to lack of Congressional support.

Even before ALS and NLS withered, a new mythology arose, the Operational Mythology.

The Operational Era

Air Force Space Command was created in 1983 and in 1990 it assumed control of the Air Force's space launch mission and its space launch test ranges. In that era there was much enthusiasm within the Air Force for moving military space capabilities into the operational realm. Space systems were unique for many years because they were specified, procured, and largely operated by the same organization, Air Force Systems Command. After years of dealing with space capabilities in a "Research and Development" context, it was reasoned that fully employing the military utility of space capabilities would require they be handled in the same manner as other Air Force systems. Transfer of launch capabilities to Space Command, "Operationalization", was one aspect of this new approach. The other aspect of the Operational Mythology would apply to not only Space Command but to nearly every aspect of the Air Force's use of space : Normalization.

Operationalization of space launch capabilities was meant to refer to the process of bringing developmental systems on line. Almost immediately the concept essentially was translated into asserting that space launch systems were the same as airplanes or ballistic missiles and proceeding from there. The launch organizations were redesigned using the new approach, including the "Objective Wing Structure" that asserted that the entire Air Force could best be operated like an operational flying wing. It was assumed that the shortcomings of the existing systems could be overcome by simply pretending...
they could be operated like F-16’s or Minuteman missiles. It even became standard procedure for every new launch vehicle procurement to contain at least optional provisions for operation of the system by uniformed military crews.

Normalization applied the Operationalization concept to the area of logistic support. Space boosters, their launch pads, and the launch ranges would be "brought into the fold" by applying the same logistic support concepts used for other operational systems. In the words of a Pentagon logistics expert "You people do everything so expensively because you don't do it like everyone else. We are going to fix that!"

Of course, there were other "advantages" which made the Operational Mythology very attractive. It arose just at the time when the post-cold war downsizing was occurring and therefore was seen as a highly attractive by certain endangered career fields. Uniformed military "operators" no longer needed elsewhere could be moved into the new mission. Air Logistics Centers facing closure could take on the new space workload to help justify their existence. At the Pentagon, the "normalized" space launch funding sources would become more easily available for the inevitable annual reprioritizations. The birds launched from the Cape and Vandenberg would feather a lot of new nests!

The Operational Mythology was immediately applied to the Air Force's newest space booster program, the Evolved Expendable Launch Vehicle (EELV), its biggest launch range upgrade effort Range Standardization and Automation (RSA), and to the reorganization of the launch organizations and ranges.

**Evolution is Better, and Besides It's a Lot Cheaper**

EELV was designed to replace the canceled ALS and NLS programs and is the latest attempt to develop an alternative to both the Missile Mythology and the Manned Mythology. The problems with the two earlier philosophies had been recognized; that was the essence of the ALS and NLS programs. ALS and NLS failed to gain adequate support not due to a renewed belief in the two older mythologies, but primarily because Congress balked at an investment of over $10 billion for what appeared to be a relatively incremental improvement over the Space Shuttle and the existing expendable fleet.

EELV resembles Big Dumb Booster, ALS, and NLS in the program's emphasis on lower launch costs as its primary objective. Unlike ALS and NLS, for EELV the lower cost is to be achieved less by technology advancements and more by careful use of existing technology. In some respects EELV is a 1990's version of Big Dumb Booster, but for the high tech era in which even bombs aren't dumb.

Some of the Operational Mythology concepts which were to be applied to EELV included standard Air Force modification management procedures, increased direct Air Force involvement in launch operations and processing, standard base supply logistics, Air Force maintenance responsibility for all ground support facilities, and delivery of only "operationally ready" and accepted flight hardware to the launch bases. In the end none of this was to be, and EELV now plans to utilize a radically different commercial style procurement approach. For the next generation of space boosters, the Operational Mythology ended before it really got started.

**Operationalization, Ended Almost Before it Begun**
There were several factors that caused the abandonment of the Operational Mythology for EELV. First, even at its most robust predicted launch rates, it became obvious that space launch is still a high value, limited volume business. Standard base supply support and dedicated military launch crews make little sense for a mere fifteen military launches a year (the target number specified by the EELV program), and even that high a rate was recognized as being unrealistic. An even more important reason was that by 1997 it became obvious that commercial launch requirements had and would outstrip those of the military for the foreseeable future. EELV would have to be, first and foremost, a commercial success for it to be viable. A commercial EELV program would exist and thrive or the program would not exist at all.

In the final analysis, resource requirements doomed the application of the Operational Mythology to EELV. The Air Force finally decided that in the era of both downsizing and a high operational tempo it could simply not to afford to "make" what it could "buy." Contractors had, did, and could continue to launch space missions, and would be doing it in any case to meet commercial requirements. But only the uniformed military could handle missions such as Desert Storm, Provide Comfort, Just Cause, and the other deployments required by national policy. This fact forced a recognition which had been apparent for some time, that the real military product and the real space mission was the data stream from space which enabled air ground, and sea forces to do their jobs, not all of the capabilities which enabled that data stream to exist. The cow doesn't have to wear a blue suit in order for the Air Force to drink milk.

The other great applications of the Operational Mythology began much earlier than EELV and thus were further along when the decision was made to abandon the concept. The huge launch range upgrade effort, Range Standardization and Automation (RSA), and the organizational restructuring of the launch organizations and ranges, largely predated the recognition of the philosophy's limitations. These approaches are being reexamined in the light of the same realizations which led to the revision of EELV. In fact, now the Air Force is planning on largely withdrawing from direct space launch operations and possibly even from the traditional base support functions. The approach being taken for EELV is intended to be the first big step toward a commercialization concept in which the Air Force would procure satellites "delivered to orbit" rather than to a loading dock. The satellite manufacturer would be responsible for procuring launch services.

The Commercial Space Launch Era

There is now a general recognition that we have entered the Commercial Space Launch Era. Rather than being the exclusive province of governments, space launch capabilities will be a commodity which can be purchased in the same manner as virtually all other elements of aerospace power. Governments will be the customers of the industry, and minority customers at that, rather than its enablers.

Why the Checkered Past?

Why in the field of space launch has the United States so often and with such energy proceeded to follow ultimately unproductive and inappropriate mythologies? There is no clear cut answer.

The Vanguard Mythology was rooted in the core beliefs of the Eisenhower Administration; the same core beliefs created NASA. In contrast, the other mythologies cannot be tied to a particular set of political beliefs. The Missile Mythology was created
by the industry and government experts involved, as was the Manned Mythology. In these cases the political leaders did not drive the mythology but, at most, approved of it. The Nixon, Ford, Carter, and initially the Reagan Administrations accepted the Manned Mythology as an element of national policy, but did not invent it. Resource considerations, in other words the amount of money available, undoubtedly greatly influenced the Missile and Manned Mythologies and the politicians certainly set those policies. But in neither case can we conclude that the mythology emanated from the top as it did for Vanguard.

In the case of the Operational Mythology, there appears to be no specific national policy which inspired it. The Reagan Administration's Strategic Defense Initiative certainly indicated an increased willingness to utilize space for military purposes, but that did not equate to the Operational Mythology. The Operational Mythology was developed within the Air Force to meet Air Force objectives, not political objectives as such.

So what drove the creation of the mythologies? It is interesting to note that in each case there existed a constituency which saw the promotion and enactment of the mythology to be in its own personal best interests. In each case there were individuals who believed that convincing others of the validity of the mythology, or at least of their particular version of it, would lead to personal advancement, power, and glory. However, this may clarify our understanding of certain aspects of the mythologies or even the enthusiasm with which they were pursued, but does not necessarily explain the basis for the development of the concepts that ultimately proved to be so wrong. There is no one reason for the creation of the mythologies; they were the products of the times and of personal interests.

The Future Mythologies?

Now that we are in the Commercial Space Launch Era, are we entering into a well reasoned approach to meeting the Nation's launch requirements or fruitlessly pursuing yet another new mythology? Only time will tell, but already there are indications that the commercial-style approach has its limitations. The Air Force's original "hands off" launch services procurement which yielded the Pegasus Small Launch Vehicle contract, had to be reworked to allow increased Air Force systems Program Office involvement following a series of launch failures. The U.S. Navy's first few "delivery to orbit" procurements resulted in the satellite being delivered to the wrong orbit (in one case) or to the right orbit, but not in working condition (in two other cases). This was good news in that Navy didn't have to pay for failed missions, but on the other hand, the capabilities the service needed weren't provided, either. The recent failures of both Air Force and commercial missions proves that space launch may be routine but is still by no means easy. The commercial-style approach now being adopted doesn't appear to be a mythology yet, but could well develop into one.

The other new item coming onto the space launch scene is Reusable Launch Vehicles (RLVs). It is asserted that RLVs will surely be the wave of the future; some have even recommended abandoning all other launch vehicle development. RLVs already seem to be developing their own mythology.

Is There An Answer?

It appears that the only answer is to recognize our national tendency to embrace new and unproven space launch ideas and also recognize the need for a logical, reasoned and technically appropriate basis for them. Mythologies may in fact be
inevitable, and we need to recognize this fact and beware. And that is the purpose of this paper.

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