A 1972 Counter for the Space Shuttle

I am probably the only aerospace engineer who still uses a 1972 Counter for the Space Shuttle (then, Space Transportation System – STS). The Counter gives a clearer picture of what has happened to our space program after Apollo. It also shows how space procurements got out of hand in the last four decades. I participated in engineering seminars that studied options for the Shuttle in 1970-71. I also participated in debugging the NASTRAN and other general-purpose computer programs, the primary design tools for the Shuttle at the time. Many people have blamed the troubles with the Shuttle and the space program on the Administrations, beginning with Nixon's in '72, and the Congress. The primary themes: insufficient budgets, lack of direction, or leadership, or cheer leading, etc.

From an engineering viewpoint, I look at budgets in simplistic terms. Depending on the budget allotted to my program, I will deliver a Cadillac or a (name a cheap car). The final product, however, must meet basic requirements (specifications), e.g., the cheap car will not explode in your face after a thousand or a million start-ups. It should do the specified job.

Go back to 1972. When the Shuttle contracts were announced, some of us were shocked. We were not shocked by the budget or even the liquid-solid propellant combination, though there were very strong feelings on both sides. What was shocking then was the time allotted to build the Shuttle. All major space contracts before the Shuttle were done in 18, 24, or 36 months. We knew the Shuttle might take longer, particularly for the development of the main engines, but we did not expect the 5 long years. If you were not directly involved in the Shuttle hardware and software, what do you do for five years?

The Shuttle was supposed (specified) to fly 60 times a year. By 1978, we knew there were major problems with the Shuttle, and it wasn't only the tiles that the media reported. Some of us left the space program to work on computers, video, communications and other hi-tech systems; where great strides were made in the last three decades.

Here is my 1972 Shuttle-Counter. After fuming over it, take a deep breath and contemplate it again. The first Columbia flight in April 1981 should have been roughly flight STS-200. The Challenger 51L in 1986, the 25th flight, should have been STS-500. The Columbia 107 in 2003 should have been STS-1500 (yes, one thousand five hundred), and so on. We should have had some 2,000 Shuttle flights by now, and not only 120-plus "problematic" flights.

Even if NASA stagnated and made no progress after 1972, there should have been a thriving aerospace private sector to build 2,000 External Tanks, 4,000 new or used boosters and, maybe, 20 to 40 Orbiters. You see, the Shuttle "specifications," the basis for the STS procurement, were finished before 1972. "Specifications" are detailed instructions to contractor(s) to build an end product that meets certain *a priori* well-defined requirements. In hindsight, the Shuttle specifications were not well defined *a priori*. With the above numbers, it becomes clear that the STS was not a bad idea. Actually, it was a brilliant idea – the correct idea for its time. At 65,000 lb per mission, we would have had over 100 million pounds launched into LEO, enough hardware, fuel and provisions to do the many things that only seem a dream today.

Forty years ago, we had intense management-engineering meetings after satellite losses. We did not have space textbooks, handbooks or Internet. We didn't even have hand-held calculators. We knew that either the space program is an advanced engineering enterprise or it is black magic. There were gaps in our technical knowledge and some of us became vigilant in identifying the gaps and eliminating them.

Over the years, I built a massive database on parts that failed on Shuttle missions. Most of the failures were not publicized nor mentioned in many studies. And when mentioned, no engineering action was recommended or taken. Technical knowledge gaps kept on widening. The slogan of the last two decades that "space systems are hard to do" is unacceptable. It was the initial charge by President Kennedy to do those things because "they are hard." Mercury, Gemini, and Apollo were hard to do. During the Shuttle era, the Jumbo Jets and the Concorde were hard to do. And so were other science and engineering undertakings.

Consider the following relevant situation. In 1983, I visited my friend Dr. Burton Edelson, then AA for Science, at NASA Headquarters. The Shuttle had flown handful times, when it should have flown about 300 missions. That indicated that there were serious problems with the program – engineering problems. Burt was familiar with my work as mathematician and aerospace engineer since 1969. *Was there anything I could do, as consultant, on the Shuttle?* He cautioned me that the Shuttle was the most politically contentious system in the agency, and I let it go. At the time, technical papers described what the Shuttle engineers were doing to increase the payload capacity of the Shuttle from 65,000 to 100,000 lb! How could the engineers increase the payload capacity of a system that flew only five, instead of 300, times? It didn't make sense. Where were the engineering priorities and direction? By the way, the boosters on the stricken Challenger were the first to fly with shaved (or thinner) booster segments to improve payload capacity. As everyone knows, the payload capacity of the Shuttle was eventually cut in half. This and other events point to misdirected engineering effort.

In the early 1990's, the office of Senator Trent Lott asked me for a written opinion on the Advanced Solid Rocket Motor (ASRM). Do you remember the ASRM? Add a segment to the Shuttle SRB to increase the thrust and performance. There were serious problems with the loads and dynamics of the SRMs. Increase the thrust, and you will magnify the problems. It was my opinion then that NASA must first solve the SRM problems before they spend money on the ASRM. The program went ahead anyway – and it was then canceled. And now, the Ares-I will use the original SRMs and the Ares-V will use the longer boosters, the ASRMs? The recent problems with the SRM's dynamics do not bode well for engineering progress.

Recent GAO studies identify knowledge gaps as serious problems in all space procurements. The engineers must step up to the plate, identify the knowledge gaps, remedy the deteriorating situation, and do their job well. Space policy and politics will then be well informed, decisive and consequential.

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