Shuttles forever? Not Exactly.

The Shuttle is an evolving system. In the current investment climate NASA is the only remaining player capable of developing a reusable spacecraft.

by Dale M. Gray

The US has announced plans to continue to upgrade and fly the Shuttle for the next 20 years. This is not to say they are expecting the Shuttle to be flying for the next two decades. NASA has learned not to throw away functioning systems like Apollo until new systems come on-line. The Shuttle has to continue to fly to assure NASA's access to space and to the International Space Station.

This philosophy comes with a heavy fiscal cost. Each Shuttle flight costs about $400 million. This cost has not dropped much in the past few years. However, the amount of mass that the Shuttle can put into orbit has just about doubled since it was introduced. This is due to evolution of subsystems such as Main Engine upgrades and three generations of lighter External Tanks. New flight software and hardware have been incorporated into the Shuttles as they are periodically upgraded.

The Shuttle is an evolving technology platform. Subsystems have been radically redesigned, even though the outward appearance of the Shuttle is little changed. However, there are physical and financial limits to technological evolution of subsystems without periodic major changes to the overarching design. We have seen this in the evolution of airplanes from canvas to steel, from bi-plane to monoplane, from propeller to jets. NASA recognizes that it is rapidly approaching subsystem design limits. Improvements can still be made, but they become more expensive and harder to implement as the system approaches the design limits.

One of the ways NASA sought to create a new generation of launch systems was the X-33. The program sought to rethink the approach to space flight and achieve true reusability. Three main infrastructure changes were sought through the program. These changes included:

- new metallic thermal protection,
- new high-powered linear aerospike engines,
- an advanced composite liquid hydrogen fuel tank.

The managers and designers sought a quantum leap in technology just as the Shuttle was a giant leap beyond Apollo technology. However, the three advanced technology tracks gave three tracks for failure while dividing the resources of the project three ways. The program managed to produce thermal protection on schedule, but the aerospike engines proved more difficult to create and test than anticipated. This hurdle was eventually overcome, but left the managerial infrastructure with few resources to deal with the delamination of the composite hydrogen tank. A substitute aluminum-lithium tank was proposed and some work done, but time and money had run out. American resolve had been removed from the program and it was allowed to expire.

Was the X-33 a failure? Hardly, the metallic thermal protection system will either be used or will be the baseline for future thermal protection systems on reusable spacecraft. The linear aerospike engines are only a few tests away from flight readiness. We now know a lot more about how composite structures respond to contact with corrosive liquid hydrogen.

It should be remembered that the original development of the Shuttle lagged almost two years behind schedule and was filled with difficulties and engineering compromises. However, NASA had to press on because it had no alternative method of sending astronauts to space -- having abandoned Apollo. Few remember that one of the first Shuttle missions was to correct the orbit of the Saturn V-launched Skylab. By the time Columbia finally launched, Skylab had reentered. Shuttle succeeded in the quantum jump in technology because it had the full national will to overcome whatever problems developed. Lockheed Martin, by comparison, had a limited budget and limited time frame. When its resources ran out, there was no ultra deep pocket available to spend through the problem and no national will to push through a solution.

NASA is currently approaching a Shuttle replacement with the Space Launch Initiative. The program seeks build on existing infrastructures by evolving systems and subsystems in a generational approach. Changes will be implemented one at a time to reduce the risk and reduce the cost. The SLI also seeks to avoid competition with private American space launch system development by seeking NASA unique missions. Because the "investment bubble" for speculative technical investments has popped, there is little money available to fund private efforts. Such events usually leave the investment field sterile for about a decade. This leaves NASA the only major player in developing a reusable spacecraft. If they can get a Shuttle replacement in the air in the next 10 years, they will have made it easier for follow-on private efforts to improve upon their methods.

What will the replacement look like? I suspect we will see a marriage between Shuttle and X-33 technology. The tile and the wings will be gone, but Shuttle avionics and other infrastructure will remain. The engines will either be evolved

Shuttle Main Engines or Linear Aerospike -- depending on the engineering approach used. One thing you can count on at this point is that advanced composites will not be used on the liquid hydrogen fuel tank. The lives saved by avoiding this material will be entirely due to the success of the X-33 program.

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