# The race is still on for a reusable rocket despite the SpaceX setback

April 22 2015, by Michael Smart

Coming in to land – and attempt to recover the first stage of the potentially reusable Falcon 9 rocket. Credit: Flickr/SpaceX

The commercial company SpaceX has now completed six successful re-supply missions to the International Space Station (ISS). Along the way it has created a lot of headaches for its competitors, who don't appear to be able to compete on a cost basis.

The latest SpaceX launch took place earlier this month. As well as delivering much needed supplies to the ISS, the company made another daring attempt to land the first stage booster of its Falcon 9 rocket on a pad in the middle of the Atlantic ocean.

While this and a previous attempt were unsuccessful, it represents the first small steps towards making a reusable space launch system.

The view from the barge shows how close the rocket was to making a landing.

Getting into space remains a very expensive activity. Exact numbers are hard to come by because of business sensitivity, but the cost of lifting "stuff" to low earth orbit is somewhere between US$5,000 and US$15,000 per kilogram.

In large part this is because all current space launch systems are expendable.

Think of purchasing a high performance sports car, using it for the first time to drive to the beach, and then throwing away the keys. This is essentially what those who operate space launch systems do.

In this situation the obvious thing to do is buy the cheapest sports car that does the job, and maybe not purchase all the optional extras. But "cheap" can sometimes mean unreliable. So there is a minimum cost below which satellite launch systems do not go in order to be reliable.

**Retrieve and re-use**

The real answer to the cost problem is to be able to drive the sports car more than once. In the case of SpaceX, it is trying to at least use part of it's space launch system again. To do this it must retrieve it in a way that it can be used again.

All space launch systems operating today have multiple stages. The first stage booster is the largest, as it lifts all the upper stages and the payload above the thick part of the atmosphere.

When the first stage runs out of propellant it drops away, and the second stage fires up and continues towards space. The first stage is therefore also the part of the system that is travelling the slowest when it is discarded. For both of these reasons, the first stage is the most cost effective part of the system to make reusable.

From the outset, SpaceX has designed all the components of its first stage booster to be used more than once. These include the Merlin rocket engines, the cryogenic tanks that contain the liquid fuel and oxidiser, plus the overall airframe and flight systems.

But for the extra expense of these parts to make sense, SpaceX must find a way get the first stage back to the launch pad. The latest flight was a second attempt at doing this.

## A tricky challenge

The scenario goes like this: The booster separates from the upper stages at approximately 80km altitude. It coasts up to approximately 160km, then begins to descend, entering the atmosphere at something like 4,500 km/h.

It uses its Merlin engines to slow it down, so it must rotate almost 180 degrees in order to fly tail first. As it decelerates in the atmosphere it deploys fins to help control its flight. After a number of burns of its Merlin engines, it approaches the landing, the hardest part.

Essentially, SpaceX is trying to land a giant cigar on a small pad in the middle of a large ocean. This is a very challenging problem!

In two attempts SpaceX has reached the landing pad, but with too much lateral velocity. The videos (above) show very clearly the difficulty of what is being attempted.

SpaceX's founder and CEO Elon Musk has now given the first explanation for why the relanding may have failed:

*Cause of hard rocket landing confirmed as due to slower than expected throttle valve response. Next attempt in 2 months.*

Clearly Elon Musk and the company don't give up easy with plans already underway for further landing attempts, with Musk pointing to video of a previous successful attempt at relanding the Falcon 9 rocket.

**Another way?**

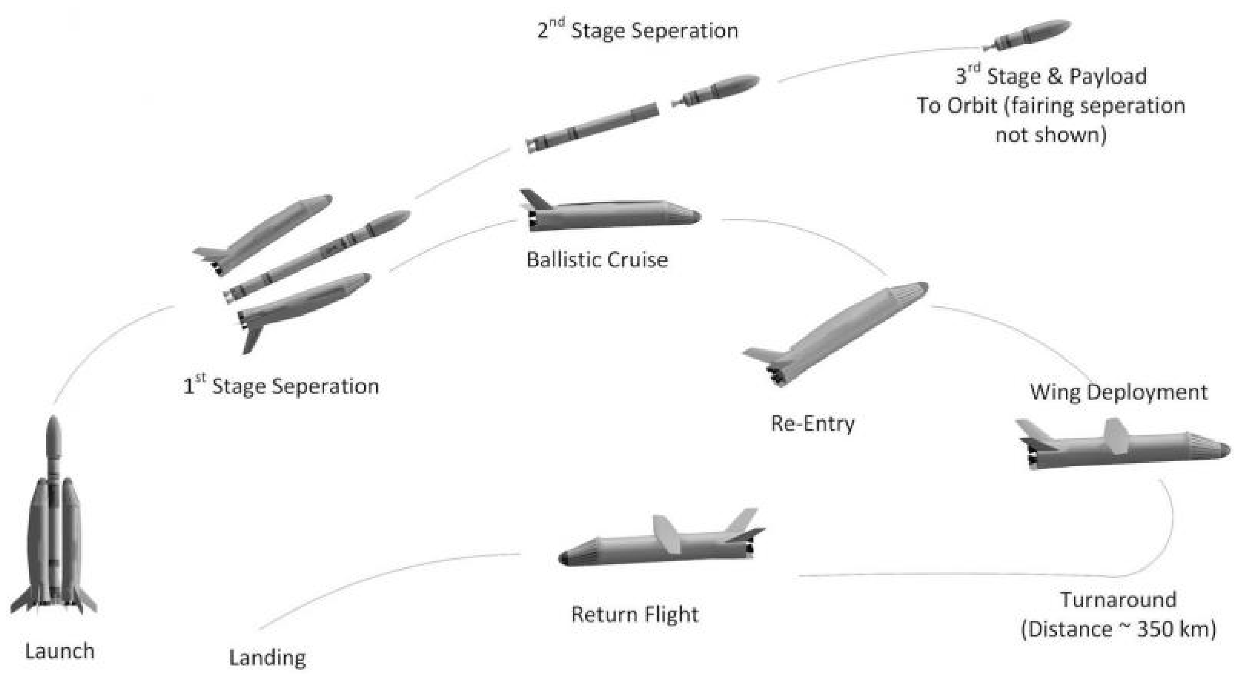
So are there other ways to retrieve rocket boosters for reuse? Yes there are. The most promising concepts make use of what are called "fly-back" boosters. These are systems that use aerodynamic lift to fly boosters back to the launch pad like a plane.

The best example of a "fly-back" spacecraft is the NASA Space Shuttle.

It flew all the way back from orbit, using it's wings to land like a glider. It required a complex thermal protection system because of its high initial velocity of 28,400 km/h. Thankfully this is not needed for a fly-back booster which re-enters at 4,500 km/h.

The University of Queensland, in conjunction with a private company called Heliaq Advanced Engineering, have recently been examining a fly-back booster that has "deployable" wings.

In this concept the booster performs a re-entry into the atmosphere with its wings stowed on top. Once it reaches subsonic velocity, it deploys the wings, as well as a propeller for propulsion. It then performs a u-turn and heads back to the launch pad under propeller (not rocket) power.




The ALV operation. Credit: Michael Smart, Author provided

This concept, called the Austral Launch Vehicle (ALV), is an attempt to bring "aircraft-like" operations to the space industry. It does not require operation of the rocket engines in the retrieval process, and is aerodynamically much simpler than the SpaceX cigar type landing.

It is also does not involve a landing on water, but gets the booster all the way back to the launch pad without any ocean going operations. The first flight of a sub-scale ALV will occur towards the end of this year in aircraft mode. The ALV is at a preliminary stage of development, but does show promise.

At this stage no commercial systems have been developed to retrieve any part of a space launch system for re-use. Hopefully numerous systems will be tried in the near future.

Regardless of which concept proves to be the best, it's great to have risk-taking companies such as SpaceX out there to shake up the status-quo.



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