

## EXPLORE

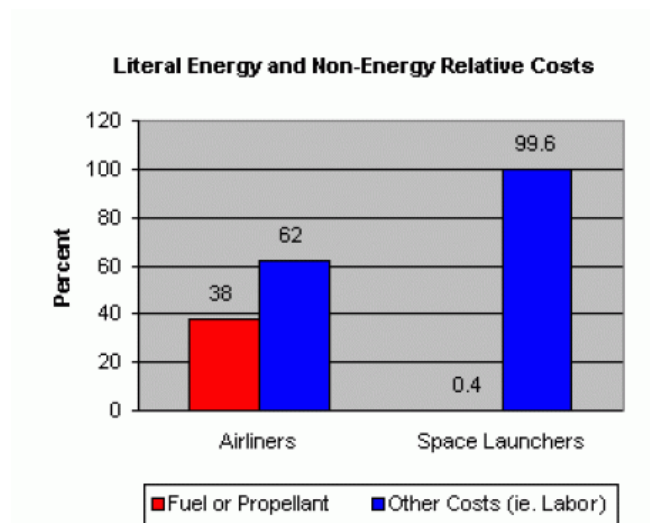
## WHY ARE ROCKETS SO EXPENSIVE?

APRIL 1, 2014 | JOSH LEE | 1 COMMENT

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Launching an object into Earth orbit is extremely expensive. The cost for a launch to Geosynchronous Transfer Orbit (GTO) is typically \$12,000 - \$18,000 per pound of payload. Even modest payloads can have truly astronomical price tags to place into orbit, often greater than \$100 million per launch. These high costs present a major obstacle to those wishing to send objects into space and have suppressed the growth of the launch market. But why *are* launches to space so expensive?

Is it the cost of rocket fuel? Fuel accounts for about 38% of the cost of operating and maintaining a commercial airliner, however, despite consuming enormous amounts of propellant, fuel accounts for about 0.4% of the cost of a launch. Maybe it's the cost of the materials that are consumed in building such massive machines? But again, this theory falls short of a meaningful answer. Materials only account for 2% of the cost. So where do these exorbitant price tags come from?



<http://home.earthlink.net/~peter.a.taylor/barchart.gif>

The first part of the answer is obvious, a fundamental lack of reusability. The rocket is the only mode of disposable transport that we humans have built. Actually, commercial airliners usually cost even more than a rocket, but they are used thousands of times before being retired. Since a launch vehicle is used only once, the entire cost of building the rocket has to be paid for in the price of its sole launch.

The second reason for high launch costs is less obvious. The margins on a launch vehicle are miniscule. Typically, a rocket can only get about 2-3% of the liftoff-mass of the vehicle into orbit. After a payload is placed on top of the rocket, there is almost no margin left for error. Every single thing on the rocket has to be absolutely precise. This means that calculations have to be checked and rechecked and rechecked again. Each and every component has to go through extensive performance testing. As a result, thousands of people are required to perform all of this work. If any single thing is wrong, even if it's just a few percentage points off, the rocket and the payload will go to the ocean floor instead of space.

Unfortunately, this tiny margin also means that there is almost no way to make a rocket reusable like an airplane or a car. Any solution to doing this requires more mass and more fuel, but there is no margin left to do this. Earth is truly an interesting planet. If it were just a bit smaller and less massive, launching objects into space would be easy; reusability would be relatively simple. However, if Earth were only slightly larger and heavier, it would be physically impossible to even launch objects into space with chemical rocket propellants.

Unlocking the technology that allows for reusable rocketry will be a milestone in history. If it is possible, it promises to reduce launch costs by at least an order of magnitude. This itself will dramatically expand the accessibility of space, and the launch market will explode with new customers. With an expanded market, economies of scale will take over, driving launch costs even lower as they become more frequent.

I have a feeling this technology is coming, and if it does finally arrive, a new space age will be upon us indeed.

Check out this Youtube video: <https://www.youtube.com/watch?v=IIVCCaYWGpk>

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## Josh Lee



Josh is currently studying aerospace engineering as a President's Scholar at the Georgia Institute of Technology. Between semesters of studying, Josh is also working a co-op at Space Exploration Technologies (SpaceX). At Tech, Josh is involved in Greek Life, campus research, and a few random clubs. He is really enjoying his time in college, but honestly just wants to graduate and work in the "real world." Josh has a strong passion for all things space-related, but his ultimate passion is human space exploration. In between bouts of Kerbal Space Program, Josh enjoys devouring any crumb of news he can find on spaceflight and related technologies. Josh's lifelong goal is to help enable permanent, human colonization of Mars and to possibly retire there with Elon. Josh dreams of the day when some crazy engineer figures out how to travel through space at faster-than-light (FTL) speeds. In the meantime, Josh really hopes we don't blow each other up and end all civilization first.

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Public opinion is really divided on the space industry issue.

Some people see it as a complete waste of time and money, while the (scientifically literate) others can't stop about it's importance and usefulness to the future of mankind.

I have a feeling you (and I) fall into the latter, and rightly so.

I mean... Spaaaaaaaaaaaaaaaaaace!!!

Who doesn't want to go there?

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