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SPACE TECH SERIES

Elon Musk & SpaceX

Reusability and the Economics of Access to Space

Rethinking the Cost of Reaching Orbit

When Elon Musk founded SpaceX in 2002, the cost of reaching orbit had barely changed in decades. Launch vehicles were expendable: their expensive engines, tanks, and avionics were used once and discarded. SpaceX set out to challenge that model by recovering and reflying the most costly part of the rocket, the first-stage booster.

Achieving a controlled landing is a demanding engineering problem. After stage separation, the booster performs a boostback burn, reorients using cold-gas thrusters, deploys grid fins to steer through the atmosphere, and executes a precisely timed landing burn to slow from supersonic speeds to a near-zero touchdown velocity. It settles onto four legs, either on a ground pad or an autonomous drone ship positioned downrange.

On December 21, 2015, a Falcon 9 completed the first successful vertical landing of an orbital-class first stage. SpaceX has since reflown individual boosters many times, treating them more like aircraft that are inspected and turned around than like single-use hardware. The Falcon 9 can deliver roughly 22,800 kilograms to low Earth orbit at a published list price near $67 million.

Reusability reshapes launch economics. Because the first stage represents a large share of a rocket's manufacturing cost, recovering it lets SpaceX amortize that expense across many flights. This drives down the cost per kilogram to orbit, which in turn makes previously impractical missions, such as large satellite constellations, financially realistic.

SpaceX has also returned human spaceflight capability to the United States. The 2020 Demo-2 mission carried NASA astronauts to the International Space Station aboard Crew Dragon. Looking ahead, the company is developing Starship, a fully and rapidly reusable heavy-lift system intended to lower costs further and enable missions beyond Earth orbit.

Part 1 · Comprehension & Analysis

1. Analyze why recovering the first stage, rather than the second stage, has the greatest impact on launch cost.

2. The passage compares reused boosters to aircraft. Explain what this comparison implies about the goal of reusability.

3. How does lowering the cost per kilogram to orbit change which missions are feasible?

4. Why is Starship described as significant for missions beyond Earth orbit?

Part 2 · Quantitative Challenge

Cost Per Kilogram to Low Earth Orbit

A Falcon 9 can lift about 22,800 kg to low Earth orbit (LEO) for a list price of about $67 million. For comparison, imagine an older expendable rocket that cost about $200 million for a mission carrying the same 22,800 kg.

1. Calculate the Falcon 9 cost per kilogram to LEO. ($67,000,000 ÷ 22,800 kg)

2. Calculate the older rocket's cost per kilogram. ($200,000,000 ÷ 22,800 kg)

3. How much cheaper per kilogram is the Falcon 9? (Subtract the two cost-per-kg values.)

4. What is the percent reduction in total mission cost, from $200 million to $67 million? ((200 - 67) ÷ 200 × 100)

Part 3 · Discussion & Extension

Reusable rockets have sharply lowered the cost of reaching orbit. Write an analysis of how cheaper, more frequent access to space could reshape the future of spaceflight. Consider both benefits (such as science, communications, and exploration) and challenges (such as orbital debris, regulation, and equitable access), and support your position with reasoning.