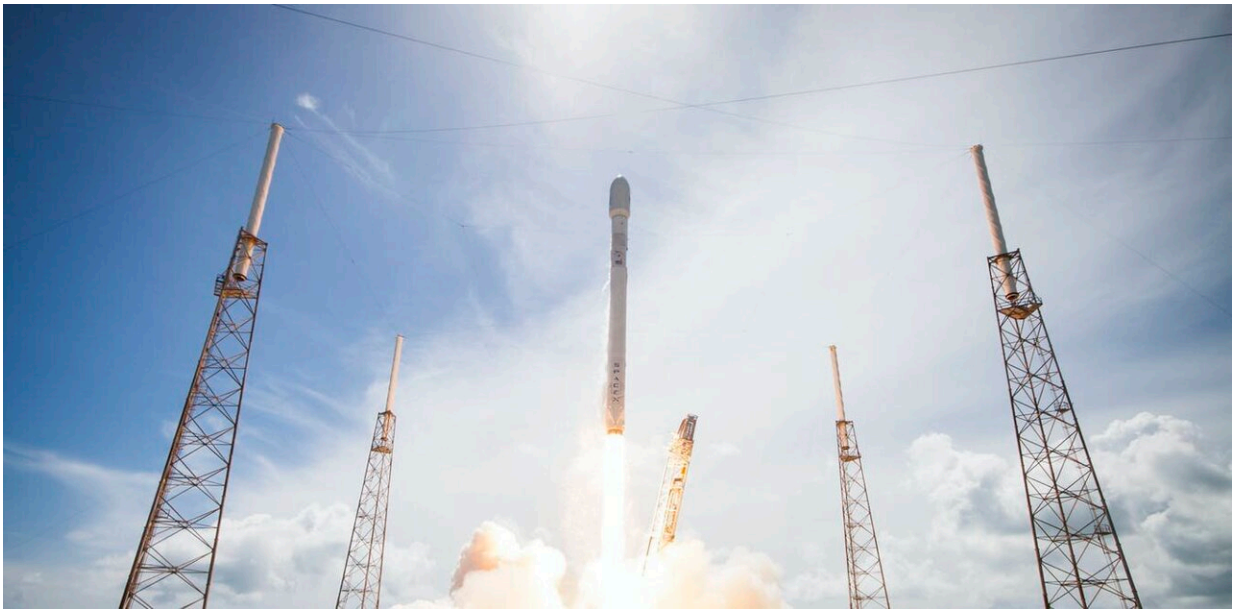
Axiom launch: Why commercial space travel could be another giant leap for air pollution

April 11 2022, by Eloise Marais



SpaceX is seeking to expand its remit to include commercial low-Earth orbit launches. Credit: SpaceX/Flickr, CC BY-NC

The Axiom-1 mission to send four private astronauts to the International Space Station is the first of many missions planned by NASA to expand the ISS for commercial use as part of what's being called the low-Earth orbit economy.

The commander of the Axiom-1 mission has emphatically stated that

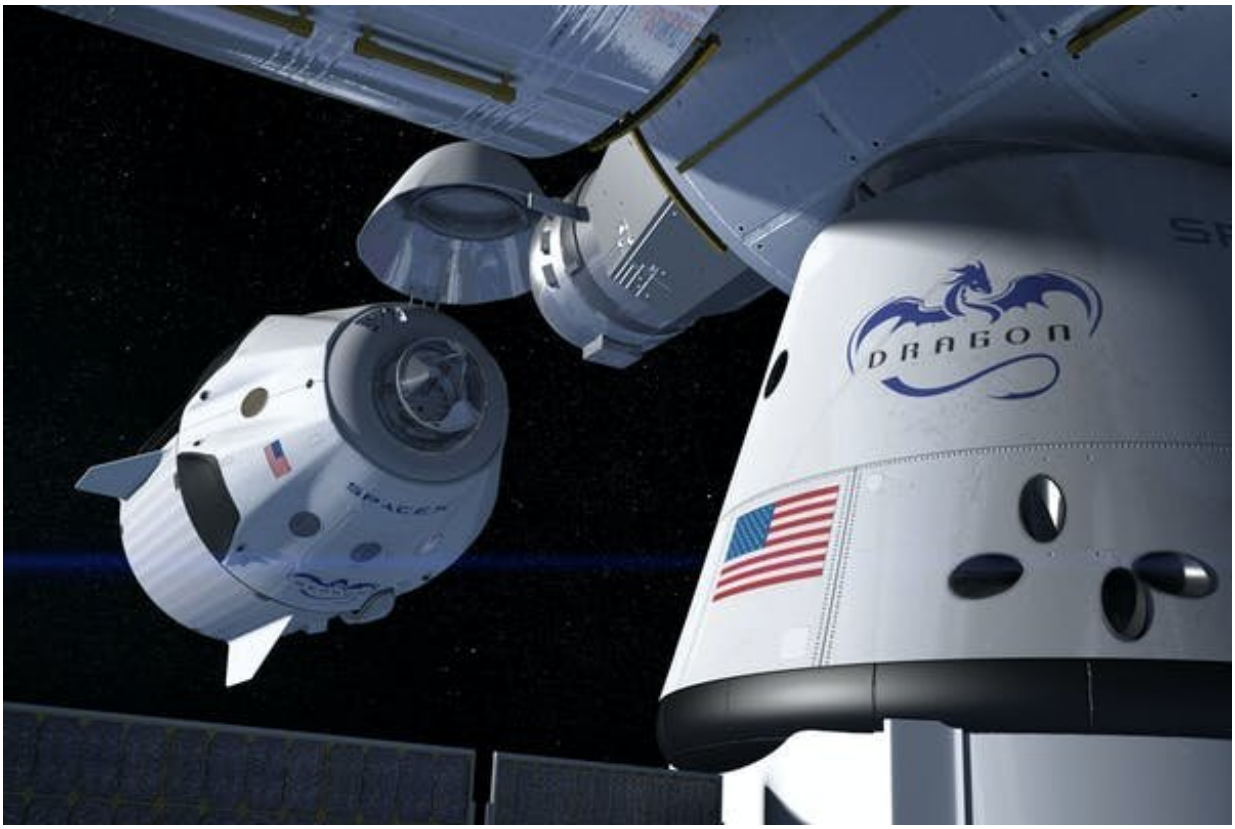
this is not an example of space tourism, as the crew have undergone training and the mission includes plans to conduct biomedical research.

Crew members—all men aged 52 to 71—reportedly paid a whopping US$55 million (£42.3 million) per ticket, an amount that would no doubt fund a formidable biomedical research program here on Earth. But beyond the ludicrous ticket price, I'm concerned about the potential environmental impacts of such space jaunts.

The mission is using a SpaceX Falcon 9 Block 5 rocket, with the crew located in the Crew Dragon spacecraft at its apex. The rocket has two stages: the reusable booster that holds most (about four-fifths) of the fuel and that returns to Earth for reuse, and a discarded second stage.

The booster reaches an altitude of about 140km before returning to Earth. The energy required to propel the spacecraft to the ISS is achieved from the combustion reaction between rocket-grade kerosene and liquid oxygen, releasing byproducts hazardous to the environment.

Rocket launches and returning reusable components release air pollutants and greenhouse gases into multiple atmospheric layers. In the middle and upper atmosphere, these can persist for years compared with equivalent pollutants released at or near the Earth's surface, which linger for weeks at most. This is because there are fewer chemical reactions or weather events to flush pollutants out of middle and upper layers.



An artist's impression of the SpaceX Crew Dragon craft docking with the International Space Station. Credit: Wikimedia

Potent pollutants

The kerosene fuel used by SpaceX Falcon rockets is a mix of hydrocarbons, composed of carbon and hydrogen atoms. These react with liquid oxygen to form carbon dioxide (CO_2), water vapor (H_2O) and black carbon or soot particles that are released from the rocket exhaust.

CO_2 and H_2O are potent greenhouse gases, and black soot particles are very efficient at absorbing the sun's rays. That means all these chemicals contribute to warming the Earth's atmosphere.

Nitrogen oxides (NO_x), reactive air pollutants, also form during launch due to very high temperatures causing a bonding reaction between usually stable nitrogen and oxygen molecules. NO_x is also produced when the rocket's reusable components return to Earth, due to extreme temperatures produced by friction on its heat shields as they whizz through the mesosphere at 40km-70km.

When these particles make contact with the ozone layer (in the stratosphere), they convert ozone to oxygen, depleting the fragile sheath that protects the planet from the sun's harmful UV radiation.

Although total CO_2 emissions from this launch will be small in comparison to those from the global aircraft industry, emissions per passenger will be around 100 times those from a long-haul flight.

Soot emissions are also much less than those from the aircraft industry, but when released into the middle and upper atmosphere, soot has a warming effect 500 times greater than at levels closer to Earth. This is in part because there are typically no clouds and few to no aerosols competing with soot to absorb the sun's rays.

The potential opportunities of creating industry and trade networks within low-Earth orbit have been likened by an Axiom co-founder to the early days of developing the internet, now an almost universally accessible technology. If we extend that analogy to imagine similarly high levels of access to the low-Earth orbit economy, rocket launches are likely to become far more common than just the 146 launches achieved in 2021.

Such a scenario would substantially alter Earth's climate and undermine our significant progress in repairing the ozone layer. At the very least, research is urgently needed to assess the consequences of a flourishing low-Earth orbit economy for our planet down below.

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