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internet, weather and communication services are the most likely to be disrupted.

HOW CLOSE ARE WE TO TRIGGERING KESSLER SYNDROME?

A UN report from 2013 projected that catastrophic collisions may occur once every five to nine years over the next two centuries. It's already happening. In 2009 an Iridium communications satellite collided with the derelict Russian Kosmos 2251 satellite, destroying both spacecraft. That event happened at about the same altitude as one of the biggest dangers: the eight-tonne Earth observation satellite Envisat. Envisat will remain in orbit for the next 150 years and there's a 15 to 30 per cent chance that it will collide with a piece of space junk in that time. Kessler syndrome doesn't necessarily have to play out quickly. These impacts could be the first domino, with crashes ramping up significantly over time.

WHAT CAN WE DO ABOUT IT?

Better regulation of new launches would help, as right now it's a bit of a free-for-all. There are existing regulations in place to try and mitigate the dangers, such as a 25-year de-orbit rule for missions in low-Earth orbit. However, ESA's Space Debris Environment Report says that less than 60 per cent of those flying in low-Earth orbit currently stick to the rules. Penalties for rule-breakers should be stiffer. Deliberately blowing up satellites needs to stop. Increased monitoring of existing space junk helps because active satellites can be moved off a collision course by firing small thrusters. Yet dead satellites are sitting ducks and there's nothing we can do to avert a collision. That's why many are calling for a clean-up job. In 2018, the British-built RemoveDEBRIS mission tested a space junk harpoon in orbit. Meanwhile, ESA has commissioned the world's first space debris removal mission. Called ClearSpace-1, it will launch in 2025 and attempt to de-orbit the upper stage of a rocket left in space back in 2013.

by **COLIN STUART** *(@skyponderer)*
Colin is an astronomy author and speaker. Get a free e-book at ***colinstuart.net/ebook***

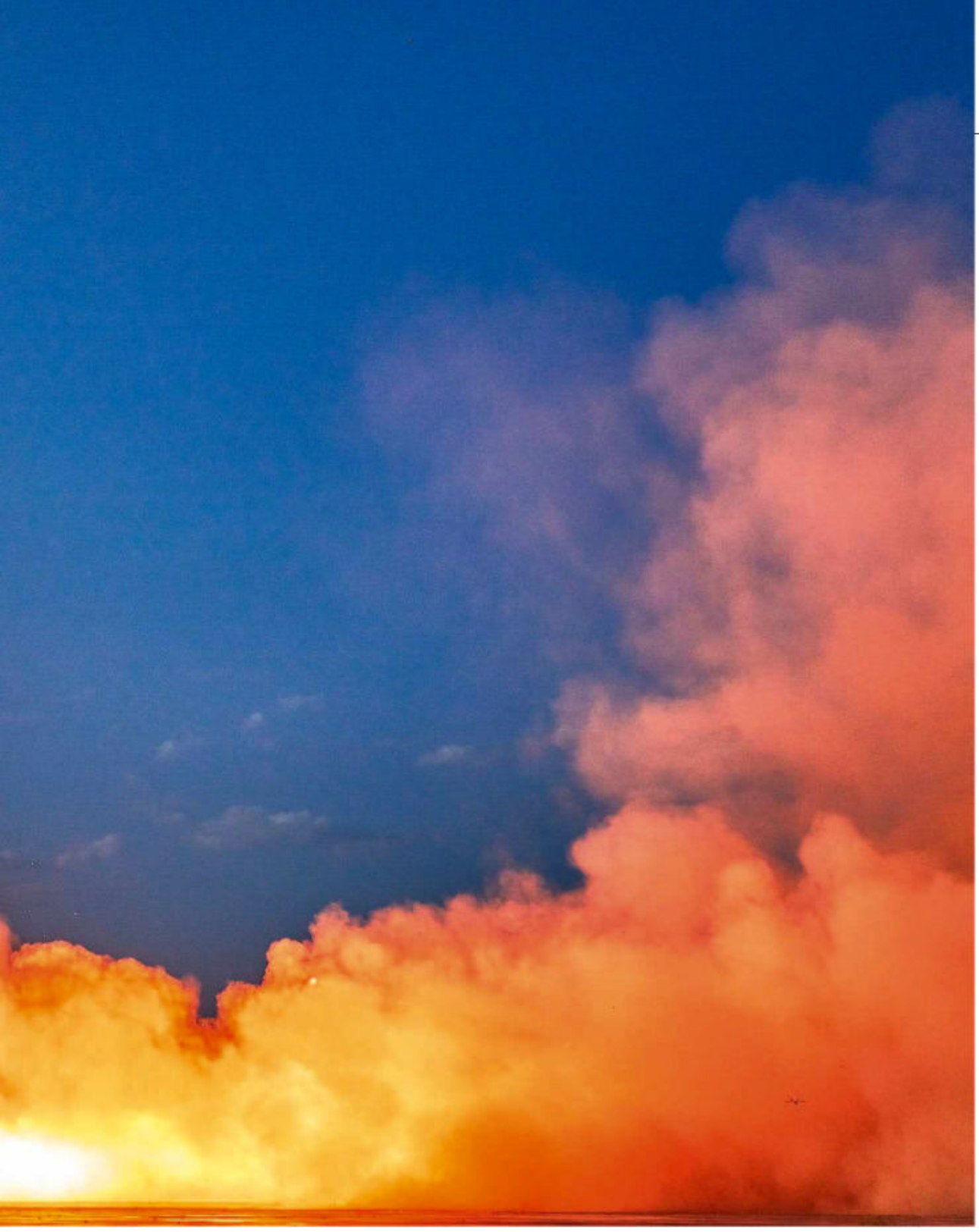
ANALYSIS

BILLIONAIRE SPACE RACE: WHAT DOES IT MEAN FOR THE CLIMATE?

New regulations regarding the environmental impacts from space travel must be put in place to prevent the emergence of a 'Wild West' attitude, experts say

Space travel made international headlines in July as both Amazon founder Jeff Bezos and Virgin boss Richard Branson flew to space in craft made by their own companies. Not to be outdone, Elon Musk's SpaceX plans to launch an all-civilian crew into orbit in September.

Commercial space travel is clearly firing up, and is predicted to become big business. Branson's Virgin



ABOVE Jeff Bezos's Blue Origin craft hit headlines when it lifted off in July

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Galactic plans to begin regular commercial services in 2022, and already has 600 reservations at around $250,000 a ticket. According to a recent analysis from Swiss finance firm UBS, the space tourism industry will be worth $4bn by 2030.

Upon landing from his suborbital flight, Bezos said the experience reinforced his commitment to fighting climate change. But what impact could spaceflight have on the environment itself?

Rockets burn through huge amounts of propellants to take off. But there are a variety of ways to launch rockets into space, so understanding the exact impacts of each craft is not always straightforward.

"With all space travel, including space tourism, the environmental impacts depend on a variety of factors that are specific to the mission," says Dr Simit Raval, a senior lecturer at the University of New South Wales and co-author of a recent analysis on space launch emissions. More research is needed to ensure a "robust understanding" of these impacts, he says.

Arguably, the two most important environmental impacts of space travel are its contribution to global warming and stratospheric ozone loss, says Raval.

According to one estimate by Dr Eloise Marais at University College London, carbon dioxide emissions

"Space exploration ignores all of us who will be left behind to suffer the consequences of an overheated Earth"

for the four or so tourists on a space flight will be up to 100 times more than the emissions per passenger on a long-haul aeroplane flight – already a carbon-intensive activity.

According to a study at the University of New South Wales, alumina particles, black carbon and even water vapour released into the stratosphere are further causes for concern when it comes to global warming. However, the overall impact is complex as some of these emissions, such as soot, can also have a cooling effect.

Paul Peeters, an associate professor in sustainable transport and tourism at Breda University of Applied Sciences in the Netherlands, says that impacts could soon add up if space tourism becomes more common. "Launches into space each have significant ecological footprints per launch," he says.

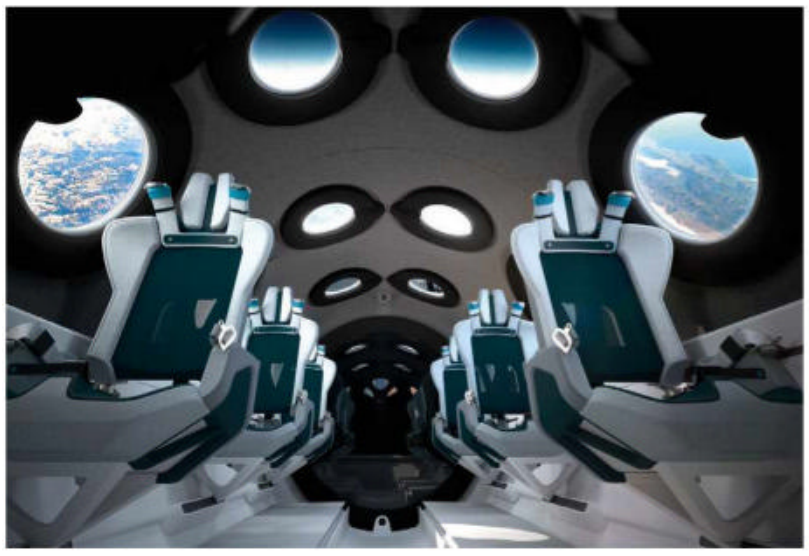
When it comes to climate change, much depends on the propellant, says Peeters. For example, hybrid rocket engines, which were used on Virgin Galactic's SpaceShipTwo, run on both solid and liquid fuel and release far more black carbon than kerosene fuel. "If hybrid rockets, which are assumed to be relatively cheap to operate, become popular, a climate disaster is looming," says Peeters.

Additional carbon emissions could also come from building spaceports, as well as from the space tourists flying to launch sites, possibly using private jets, says Annette Toivonen, tourism lecturer at Haaga-Helia University of Applied Sciences in Finland.

Alongside the climate impact, rocket launch exhaust plumes contain other substances which can deplete the Earth's ozone layer, such as nitrogen oxides, hydroxyl radicals and water. Emissions from space launches are not yet specifically addressed in the international Montreal Protocol, which addresses substances that deplete the ozone layer.

There can also be local pollution impacts at launch sites. For example, the long term use of unsymmetrical dimethylhydrazine (UDMH) rocket propellant at the Baikonur Cosmodrome spaceport in Kazakhstan led to severe environmental damage.

There are currently no global regulations or agreements regarding pollution or other environmental ➤



Virgin claims its spacecraft's cabin is designed for the "astronaut experience" with individual seats for g-force management

impacts from space travel.

"The current rise in private new space activities has created an increased demand to avoid a 'Wild West' attitude and ownership," says Toivonen. New types of regulations and legislative frameworks are needed, she says, including globally binding space-tourism legislation.

The US billionaires pushing space tourism claim that they offer hope and even future positive consequences for people around the world. Bezos has argued that space travel will help children "build a future", while Branson has said that private space travel will be "open to everyone".

Private space launches have certainly piqued the interest of many people. An analysis by Media Matters for America found that broadcast morning television in the US spent nearly as much time on the July Bezos space launch in one day as on the entire climate crisis in the whole of 2020. However, Evlondo Cooper, senior writer for Media Matters, says Bezos's space flight was a missed opportunity to cover both issues.

"Space exploration is exciting; but the undue attention given to those who can leave our planet too often ignores all of us who will be left behind to suffer the consequences of an overheated Earth driven by our world's polluting industries," he says.

Bezos has even argued that "all polluting industry" should be moved into space to keep Earth clean. But transporting heavy industry into space and then shipping the products back to Earth would require massive use of energy and resources.

While space travel will have the potential to become more energy-efficient or greener, it will still add to the environmental pressure on our planet without improving the quality of human life, argues Peeters.

The best decision, he says, would be to agree internationally that commercial space travel is "not a wise development" due to the current ongoing environmental and health crises.

—

by **JOCELYN TIMPERLEY**

Jocelyn is a freelance climate journalist, based in Costa Rica.

COMMENT

MENTAL HEALTH: HOW CAN WE HELP ELITE SPORTS COMPETITORS STAY WELL?

Elite Olympic athletes recently highlighted the mental health issues they faced. A psychologist explains how we could help them

Recently, mental health in sports was thrust into the public spotlight when Olympic gymnast Simone Biles and tennis star Naomi Osaka both chose not to compete, citing concerns over their mental wellbeing due to the pressures of elite competition.

Both athletes strongly expressed concerns over the ongoing effects of being in an intense competitive environment, and both argued that a deterioration in mental health is a legitimate reason for withdrawing from competition.

Although some reporters have been less than sympathetic, arguing that these highly paid athletes should accept and deal with the pressure, we should not be so easy to dismiss the notion that elite sportspeople need support for their mental health. After all, regardless of their talents, athletes are human beings just like the rest of us, and being able to play sport at an elite level does not provide immunity to poor mental health.

Some commentators have said that the two athletes simply lack mental toughness. But arguably, withdrawing from such high-profile competition after years of training and preparation was a more difficult decision to make than to go ahead and compete. Moreover, if they had cited a physical injury, such as an injured knee, their withdrawal would not even be questioned.

So why are elite sportspeople under so much pressure, and how can we learn from this experience to provide better mental health provision?

To do this it is important to understand the factors that make elite sporting competition such a highly pressured environment. First, competitions are won and lost in mere moments. Consider a gymnast with their sights set on Olympic gold, for example. One slip, or one lapse of concentration, and that ambition is gone in an instant.

Athletes spend years training to perform to the best of their abilities in that one specific moment. When you add to that the fact that they are representing an entire country, and that they feel that the focus of thousands, including their family and friends, is

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