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THE TALIBAN'S NEW 'AIR FORCE'

GA INNOVATION SHOWS THE WAY

AN eVTOL BUBBLE SET TO BURST?

COULD THE URBAN AIR MOBILITY SECTOR BE HEADING FOR A HARD LANDING?

ROYAL AERONAUTICAL SOCIETY

Making spaceflight more sustainable

With the number of launches into space likely to soar in the coming years, how much focus within the sector is being given to reducing the environmental impact of this activity? MICHAEL JAEGER, a partner and patent attorney in the electronics, computing and physics group at European intellectual property firm, Withers & Rogers, investigates.

The global space launch services market was valued at nearly $10bn in 2019 and is projected to reach in excess of $32bn by 2027, with small satellite launches driving a major part of this growth. A report published recently by the Highlands and Islands Enterprises, the economic and community development agency for the North and West of Scotland, estimates that over 970 rockets will be used to launch almost 4,000 small satellites from the UK alone by 2031.

In addition to an increased demand for satellite launches, space tourism and long-haul space transport are also likely to contribute to a dramatic increase in rocket launches over the next decade and beyond. With Virgin Galactic, Blue Origin and SpaceX all launching space tourism services in 2021, it has been predicted that the global sub-orbital transportation and space tourism market could reach $2.58bn by 2031. Moreover, since SpaceX announced that its upcoming Starship vehicle could be used for rapid long-haul transportation on Earth, it has been estimated that the long-haul travel-by-space market could ultimately reach $15bn per year.

The carbon footprint generated by this rapid increase in activity cannot be ignored. A single rocket launch can release up to 300 tonnes of carbon dioxide into the upper atmosphere, where it can remain for years. Although the annual amount of CO_2 emitted during rocket launches is currently a mere 1% of that emitted by the aviation industry, other pollutants that are commonly released during these launches, such as soot and aluminium particles, may have damaging effects on the environment at their current rates of emission.

With demand for rocket launch activity growing strongly, the space sector is starting to develop wide-ranging technologies to help improve its sustainability.

The impact of rocket fuel

Kerosene-based rocket propellant-1 (RP-1) is a widely used rocket fuel, such as in SpaceX's Falcon 9 rocket, which emits significant amounts of black carbon particles or 'soot' when burned during launch. These soot particles can remain at altitudes of 30-50km and can be carried into global circulation patterns. UK-based aerospace company, Orbex, claims that 120 rocket launches emit as much soot as the entire global aviation industry emits in a year.

Solid rocket boosters, such as those used on the Space Shuttle and in NASA's upcoming Space Launch System (SLS) vehicle, tend to burn a mixture of aluminium and ammonia, which release large, heavy particles of aluminium into the upper atmosphere.

The particles of soot and aluminium released into the pristine upper layers of Earth's atmosphere during launches can absorb and reflect incoming solar radiation in the stratosphere, which can lead to changes in temperature and radiation levels both at high altitude and at the Earth's surface. These changes can, in turn, harm the ozone layer, as a warmer stratosphere can increase the rate of chemical reactions that reduce ozone.

Rockets burning a mixture of liquid hydrogen and liquid oxygen are widely considered to have the least environmental impact, since they emit mainly water vapour. However, even water vapour may not be benign when emitted into the upper atmosphere, as it could affect the properties and processes of the mesosphere and ionosphere. Moreover, the energy density of liquid hydrogen is much lower, compared to other more polluting rocket fuels, and therefore is unsuitable for launching heavier loads into space without the use of additional solid boosters.

Search for alternatives

Alternative 'greener' rocket fuels may form part of the solution to improving the sustainability of space launch. To date, a small number of such fuels have been developed.

In the UK, Orbex has developed a renewable bio-propane fuel that cuts carbon emissions by 90%, compared to other hydrocarbon-based fuels. Importantly, the fuel also almost entirely eliminates soot emissions. This low-carbon low-soot fuel will be used to launch the company's Prime space rocket from Space Hub Sutherland in the North of Scotland.

Another UK-based space company, Skyrora, has developed Ecosene, an award-winning synthetic form of RP-1 kerosene, produced from non-recyclable plastic waste. The company claims that its Ecosene-fuelled rocket engine, which uses hydrogen peroxide as an oxidiser, produces about 40% fewer emissions overall, including carbon dioxide, carbon monoxide, soot and sulphur.

Innovative launch technology

As well as the search for alternative fuels, space companies have been exploring innovative launch technologies which may help to improve the sustainability of access to space.

Among them, UK-based Reaction Engines has developed the SABRE engine, which is capable of operating in both 'air-breathing' and 'rocket' modes to launch a vehicle from the ground to 25 times the speed of sound in space. The SABRE engine, aspects of which were granted patent protection by the European Patent Office in 2019 (EP3055544), as well as in the US (US9810153), includes an innovative precooler capable of rapidly cooling incoming air from 1,000°C to ambient for supply to a ramjet system while in 'air-breathing' mode.

During the initial stages of launch, the engine will benefit from the greater fuel efficiencies provided by the ramjet system compared to a conventional rocket engine. Moreover, since the SABRE engine requires no liquid oxygen while in 'air-breathing' mode, the launch vehicle is required to carry less liquid oxygen in order to reach space, reducing the weight of the vehicle and thus its overall fuel consumption.

With patents pending in Argentina, China and Europe, and a patent granted in the US (US10059472), California based company, SpinLaunch, is developing a mass acceleration system for launching fully faired rockets into low Earth orbit. The system operates by spinning the rocket in a vacuum chamber at nearly 5,000mph, before releasing it via an exit tunnel. The rocket progresses to high altitudes under its own inertia, at which point the projectile sheds its fairing to reveal the engine which is then ignited to accelerate the rocket into orbit. Since rocket power is not required to launch the projectile through the lower and denser layers of the atmosphere, emissions during launch should be drastically reduced. Once operational, this innovative rocket launch system will be particularly effective at launching small satellites into space (see Pushing the Envelope, p11).

There is no doubt that the rocket launch sector is involved in some particularly dynamic and exciting R&D activity in a bid to give individuals and businesses greater access to space in the future. As demand for space traffic grows, it is important that steps are taken to minimise its environmental impact. For those businesses working on ways to improve the sustainability of space traffic, securing patent protection for green innovations at an early stage, could generate significant commercial rewards in the future.

SpaceX