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HOME OVERVIEW NEWS RESEARCH LAUNCHERONE MULTIMEDIA OUR TEAM BOOKING

OVERVIEW

Environment
History
Safety
Spaceships
Spaceport
Training
Space Tickets
Experience
Environment
Dow nload our Brochure

Making Space for Earth & the Environment.
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Space Matters!

Planet Earth faces its gravest challenge yet - a burgeoning global population with an insatiable hunger for dwindling levels of finite resources. While there is no single silver bullet to remedy this situation it is becoming increasingly clear that in the future, mankind will have to make better use of "off-planet" resources.

In the last 50 years, our quality of life has been immeasurably and positively influenced by man's first childlike steps into the world outside our world. Without satellite technology our ability to even attempt to feed the global population or to understand the pace and nature of climate change would be severely curtailed. However if we are to exploit fully the huge potential that space holds, there needs to be a dramatic and rapid change in the old, dirty and dangerous technology that has been used to put people and payload into space for half a century.

Virgin Galactic is a unique, clean-tech project which has as its mission the transformation in safety, cost and environmental impact of access to space for people, scientific research and small satellites. Its willingness to invest and to take risk is already pushing the pace of change where government agencies and traditional industry have stalled. In achieving its mission, Virgin Galactic will also act as a test-bed for new and clean technologies, such as the use of carbon composites in large aircraft, which have applications across a range of industrial sectors. This is why Professor James Lovelock, renowned environmentalist and author of The Gaia Theory, describes Virgin Galactic as one of the most important industrial projects of the 21st century.

Our Space launch system.

Virgin Galactic's commercial space launch system is based on the world's first private manned spaceship which successfully flew to space and back three times during 2004.

The system radically overturns much of the traditional thinking behind 50 years of space launch and as a result is cleaner, cheaper and safer by design.

Air launch - avoids the need for large, dirty ground-based rocketry. Carbon composite construction - four times the strength of steel but � of the weight; transforms the energy requirements for both launch aircraft

(WhiteKnightTwo) and spaceship (SpaceShipTwo). Hybrid rocket motor - benign, non-toxic fuels with a high altitude and short burn time due to air launch. Unpowered descent and landing. Fully reusable

These features add up to a system which can be described as environmentally benign compared to any form of space launch technology, manned or unmanned that has ever existed. In terms of carbon footprint, current calculations suggest that emissions per passenger, per trip, will be approximately 0.8 tonnes - less than a oneway flight from London to New York. Approximately 70% of this results from the WhiteKnightTwo rather than the SpaceShipTwo.

WhiteKnightTwo is already the world's largest all carbon composite aviation vehicle and the most fuel efficient of its size. However due to the experimental license under which it operates, it will provide an ideal platform for the testing and possible first regularized commercial use of a sustainable, renewable jet aviation fuel that is being developed elsewhere in the Virgin Group. Success in this area will reduce further the system's already low carbon footprint.

Virgin Galactic's home will be at Spaceport America in New Mexico. This Foster & Partners building has been designed with energy efficiency including extensive use of renewables at its core.



Designed and built with revolutionary, but proven thechnology for Virgin Galactic in Mojave USA, SpaceShipTwo's arrival will launch Earth's first Spaceline - Photographed by Ned RocknRoll.

Our Markets *Space Tourism.*

The opportunity to allow many thousands of people from around the world to experience space for themselves presented the first readily available market to Virgin Galactic without which the project would not have been possible. Our early customers are therefore the pioneers and enablers of a new and vitally important industry.

To date, fewer than 500 people have experienced space travel but almost without exception, those that have been have returned to earth with a heightened awareness of the nature and vulnerability of our planet. Seeing it from out there, surrounded by the incredibly thin protective layer of atmosphere, helps to waken one to the fragility of the small portion of the planet's mass that we inhabit and the importance of protecting it. Bringing this experience to a far wider constituent will, we believe, extend and encourage this perception. Virgin Galactic attracts high levels of media interest which will assist promoting this message to the world at large.



Science.

Virgin Galactic aims to support low gravity and near-space scientific research through its space launch systems. In particular, access to the upper atmosphere from the limit of commercial aviation flight (~40000ft or 12km) to the edge of space at ~100km is very limited. Balloons cannot reach the upper Earth atmosphere, and orbital vehicles fly too high. Ground based measurements e.g. with lasers and rocket experiments into the region have either limited sensitivity or duration respectively. However the upper atmosphere is the "gateway" that connects Earth's environment and space, where great surges of energy meet, from the Earth surface radiating back into space, and energy from the sun and interplanetary space traveling inwards. A specific region of the upper atmosphere, the mesosphere (50-90km) is a highly sensitive indicator of global atmospheric temperatures, thus might act as the 'canary in the coal mine' where climate change is concerned. Virgin Galactic aims to revolutionize regular access to this region for scientists and their experiments, thus greatly enhancing our ability to understand climate change and determine mitigation strategies.

Further, the ability to travel suborbitally and experience periods of nearzero or 'microgravity' can enable a range of valuable scientific experiments currently performed by sounding rockets or at great cost using the long duration space station or space shuttle. Microgravity science can address problems such as protein folding which is instrumental in developing designer drugs to combat a host of diseases; and designing new materials for transportation, computing and biomedicine. The space launch system under development will allow more detailed, affordable and frequent 'human in the loop' microgravity science experiments. These have the potential to rapidly advance several areas of science that have stagnated in the last few decades due to poor access to space.

Rocket Motor Emissions

During 2010. a report entitled "Potential Climate Impact of Black Carbon Emitted by Rockets" was submitted to the American Geophysical Union. It looked at the possible atmospheric effects of black carbon deposits from sub-orbital space vehicles using hybrid rocket motors and attracted some media comment.

Virgin Galactic has always regarded the total environmental impact of its new vehicles as well as their significant environmental benefits to be a core element of the chosen design.

The WK2/SS2 system represents a huge step-change in energy efficient aerospace design and technology through the unprecedented use of carbon composites, air launch and a re-entry design that ensures reusability, the elimination of all toxic emissions and a carbon footprint per flight which is so small to be of no real significance.

The report is from a well respected source and looks at an area of potential environmental impact which is certainly important to study. However it is also an early stage, speculative discussion paper by and for the scientific research community. The lack of any real data and the many unknowns mean that the range of uncertainty in the models is enormous. The research uses a fuel mass and type which bear little resemblance to the SS2 rocket motor but this is almost irrelevant compared to the uncertainties in the science itself. So while it is timely to consider these effects it is premature to make any firm statements on the magnitude of the impacts - the results are simply too uncertain.

There are two further points of significance:

First is that these emissions are not unique to hybrid rocket motors and sub-orbital spacecraft whether they are being used for space tourism or not. They actually occur to a greater or lesser extent in all rocket motors and in particular to the solid rocket boosters that have been used since the earliest days of space exploration. The Space Shuttle alone which has undertaken over 120 missions in the past 30 years contains 2.5m lbs of solid fuel compared to around 15000lbs in SS2. Any potential impact in this area from the proposed number of flights of SS2 over many years is therefore of pinprick significance compared to the existing annual activity of just one current government vehicle - and that's before any other environmental impact is taken into consideration.

Our Future.

Virgin Galactic's plan for sub-orbital space launch represents just a first step and much more will need to be done in the future if we are to reap the greater benefits that space offers. The next steps will take significant new private sector investment which we believe will be readily available if Virgin Galactic is a commercial success. It is clear from industries such as mobile telephony that once technologies are unlocked from government control and exposed to private R&D and investment, innovation and change can rapidly follow.

potentially achievable in a relatively short time frame. How short will depend to a large degree on the early and visible success of Virgin Galactic and other similar cutting edge initiatives

transformational technologies resulting from improved space access are

We believe that space is no exception and that a wide range of

Back to top

SS1 photographed by Ron Dantowitz

Secondly, our current lack of understanding of climate science, particularly as it pertains to the upper atmosphere is precisely because we do not have the vehicles available to undertake frequent and cost effective atmospheric research. Virgin Galactic's vehicles will open up unprecedented access for scientists to this area known by NASA as the "Ignoresphere". It has the potential to transform our understanding of the causes and effects of climate change, including the possible effects of rocket motors, over a very short period of time. It will also allow us to evolve and refine rocket motor fuels and designs if necessary and continue to improve access to space for the benefit of humanity in a way which continually improves the environmental impact of this essential activity.