

Virgin Galactic and Sub-Orbital Science**Stephen Attenborough**

Virgin Galactic was founded by Sir Richard Branson to open spaceflight to a much larger group than ever before. Its aim is to transform space transportation and human spaceflight by creating a profitable company that establishes new standards for spaceflight safety, frequency, flexibility and cost. The designs of the Virgin Galactic spaceflight system and its operations have been built to be flexible in payload and mission profile. As such, they are extremely well suited to the execution of human-tended and autonomous science experiments as well as for space tourism – a market that Virgin Galactic (VG) has successfully established with over 300 paid up customers and more than \$40M in deposits.

- VG is the only company building spaceflight vehicles based on a prototype that has already flown to space successfully (SpaceShipOne). Our new system also consists of a carrier aircraft (WhiteKnightTwo - WK2) and an air-launched spacecraft (SpaceShipTwo - SS2).
- Construction and testing of the prototype vehicles for Virgin Galactic's commercial operations is substantially progressed. WK2 is nearing the end of its test flight phase and SS2 will be rolled out for the first time in Dec 2009 prior to commencing its own test flight programme.
- SpaceShipTwo has generous payload capacity (2000+ lb) and large cabin enabling freedom of movement without restraints, with seating for six passengers and two pilots.
- Virgin Galactic's plans are centred and founded on significantly higher levels of safety than any previous spaceflight system. The safety case is built on core characteristics of the system: Air launch, glide to land, composite construction, and patented feathered re-entry system, as well as extensive operations experience of the Virgin Group.
- Virgin Galactic has been funded to date by the Virgin Group, a large branded venture capital organisation, which provides a solid funding stream for the project. In July of 2009, Virgin Galactic announced that it had concluded a deal (subject to regulatory approval) with Aabar Investments, an Abu Dhabi based investment fund which will see Aabar take a 32% stake in the company for \$280m. This secures the necessary funding to complete the development.
- Virgin Galactic is built on and leverages the Virgin Group's extensive operating experience: global airlines such as Virgin Atlantic and Virgin Blue, train services such as Virgin Rail, and customer and tourist services around the world.
- Virgin Galactic is the farthest along as a developed business of any suborbital spaceflight provider, over 300 reserved tourism customers, representing more than \$40 million of deposits, and an additional 85,000 expressions of interest.
- A comprehensive human training centrifuge program has successfully proven the accessibility of spaceflight to a wide diversity of individuals.

The VG suborbital service is well-suited to scientific research and engineering test processes. Such research could include atmospheric science, meteorological science, life or other science associated with macro and microgravity, astronomy, heliophysics, and earth and planetary science. Other applications could include a cost effective means for testing and verification of equipment for orbital and exploration programs, as well as practical training on such equipment in microgravity. Virgin Galactic's suborbital spaceflights will provide a cost-competitive alternative to sounding rockets with the addition of a human interface environment and a longer window in microgravity for useful training

VG will be able to offer researchers several services:

Researchers will be able to tend their experiments in space by mounting them inside the SS2 flight cabin. SS2's large volume, substantial payload, and multiple windows make the cabin well-suited to a variety of research goals.

Researchers will be able to mount experiments in the unpressurized aft bay of the vehicle for exterior research. Such experiments can take atmospheric samples either inside the bay or eventually via a window enabling access to the airstream.

WK2 will offer an excellent proving and training environment for SS2's cabin, as well as an excellent high-altitude research platform in itself. WK2's cabin is virtually identical to that of SS2.

Researchers will be able to order the management of experiments by VG staff.

of personnel on specialized equipment or mission scenarios.

The SS2 / WK2 system offers the following positive characteristics as a platform for science research:

- The system's characteristics and competitive price enables rapid vehicle turnaround and high flight rate, which can support series missions in quick succession, even back to back.
- The operational flight frequency anticipated offers very short lead time to actual flight and also offers flexibility in scheduling. In other words, the launch window can be tailored to the individual researcher and/or the experiment.
- The system's characteristics also enable 'science of opportunity', such as the study of meteor showers, supernovae, specific climate conditions.
- The system will be competitive in price to sounding rockets.
- Services provided via the SS2 / WK2 system offer more microgravity time than parabolic flight and drop towers, without the associated infrastructure costs.
- WK2 and SS2 provide a useful environment for training on such equipment, giving adequate time to trial functionality and specialist tasks (particularly compared to parabolic flight).
- WK2 is capable of parabolic flight and macro g for researcher training and experiment test.
- As the WK2 and SS2 cabins are very similar, equipment training or mission planning can be carried out in the WK2 prior to an SS2 flight.
- The high-altitude, large capacity and anticipated frequent flight of the WK2 system provides an attractive research platform on its own.
- All data and equipment is recoverable from VG flights.
- SS2 has the ability to maneuver in space through its RCS system
- Down range flight trajectories may become an option in the future and would support extended time at specific altitudes of interest.

Virgin Galactic plans to use the air-launch system architecture demonstrated successfully by Scaled Composites during the SpaceShipOne / White Knight One program. In this architecture, a purpose-built carrier aircraft powered by commercial jet engines carries the spaceflight vehicle to launch altitude (approximately 45,000ft). The spaceflight vehicle is air-launched from the carrier vehicle and fires its rocket motor, executing a turn for a steep climb. The spaceflight vehicle conducts a ballistic arc into space, and deploys its unique and patented 'feathered' configuration for re-entry. Following re-entry and descent into atmosphere, the spaceflight vehicle de-feathers and glides to a horizontal landing at its home base.

With proper spaceport and commercial licensing, the SS2 / WK2 spaceflight system will be capable of operating from any typical airfield with a runway of more than 9,000ft. Specialist equipment is limited to the SS2 oxidizer fuelling system and ground loading fixture. Commercial operations will be centered at New Mexico's Spaceport America, being constructed adjacent to the White Sands Missile Range.

Spaceport America has many advantages for science-focused flights. These include: (1) Clear surrounding airspace due to remote location & proximity to White Sands Missile Range; (2) Excellent weather conditions conducive to high flight frequency and rapid turnarounds. (3) Distance from major urban areas positive for certain climate and astronomy work, due to low urban particulate contamination and light pollution. (4) Relatively high altitude of site (approx. 4,000 ft) (5) WSMR has extensive technical facilities to augment scientific research via SS2 and WK2. And (6) As "Anchor Tenant", Virgin Galactic is involved closely with the development of the Spaceport and so can ensure that any specific operational requirements are taken into account.

Virgin Galactic has identified the following specific science areas for potential investigation: Climate science/meteorology/aeronomy/ ionospheric science; Microgravity science Astronomy/Solar Physics; Planetary Science; Earth observation. More application may exist as well; we look forward to hearing your ideas.